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MONGOLIA THE NEW WORLD

By Professor WILLIAM K. GREGORY

AMERICAN MUSEUM OF NATURAL HISTORY

PART I

WHEN Roy C. Andrews made his first journey to Mongolia in 1916 he could hardly have dreamed of the far-reaching scientific results that would eventually grow out of his determination to explore the Gobi region on a larger scale. For since then he and his associates of the Third Asiatic Expedition of the American Museum of Natural History have literally opened up a new world to science. All previous explorers had reported the Gobi desert as barren of fossils, but Andrews and his colleagues have discovered a long series of fossil-bearing basins representing many millions of years and containing a superbly preserved record of animal life. The geologists and geographers of the expedition, mapping every mile of the thousands traversed by the expedition, photographing and drawing the present topography of the mountains and great basins and collecting an equally full series of rock samples for laboratory sectioning and analysis, have literally brought home the record of the entire earth history of northern Asia; meanwhile the archeologists of the expedition have recovered highly significant relics of prehistoric man.

Now that a considerable part of the Third Asiatic Expedition's collections have been worked out of the rock and the specialists have published a series of technical reports upon their results to date, it seems timely to attempt a broad general account of these discoveries and to indicate how they may be connected with similar investigations in other parts of the world.

THE PENEPLANES OF MONGOLIA

The "peneplanes of Mongolia," as described by Professor Berkey and Dr. Morris, may well be selected as the take-off for our airplane survey of the country. Whenever the rock strata of the earth's outer crust become crumpled up into mountains, or whenever a given region is "block-faulted" upward, the increase in general level of that region rejuvenates the forces of erosion. Heat and cold, moisture, frost, wind and rain, all aided by gravitation, renew their age-long work of breaking and pulverizing the rock, of scouring river channels and of carrying the detritus down to lower levels until it is swept out to sea, there to form great sedimentary beds of sandstone, limestone, etc. As long as there is no further general disturbance of level these processes continue to wear down the mountains and uplands. Meanwhile the gradients, or general slopes of the rivers, are being reduced, the rivers become too sluggish to carry their full loads of sediment down to the sea and the lowlands become filled up with the sediments brought from the uplands, until the "base level of erosion" is ap-

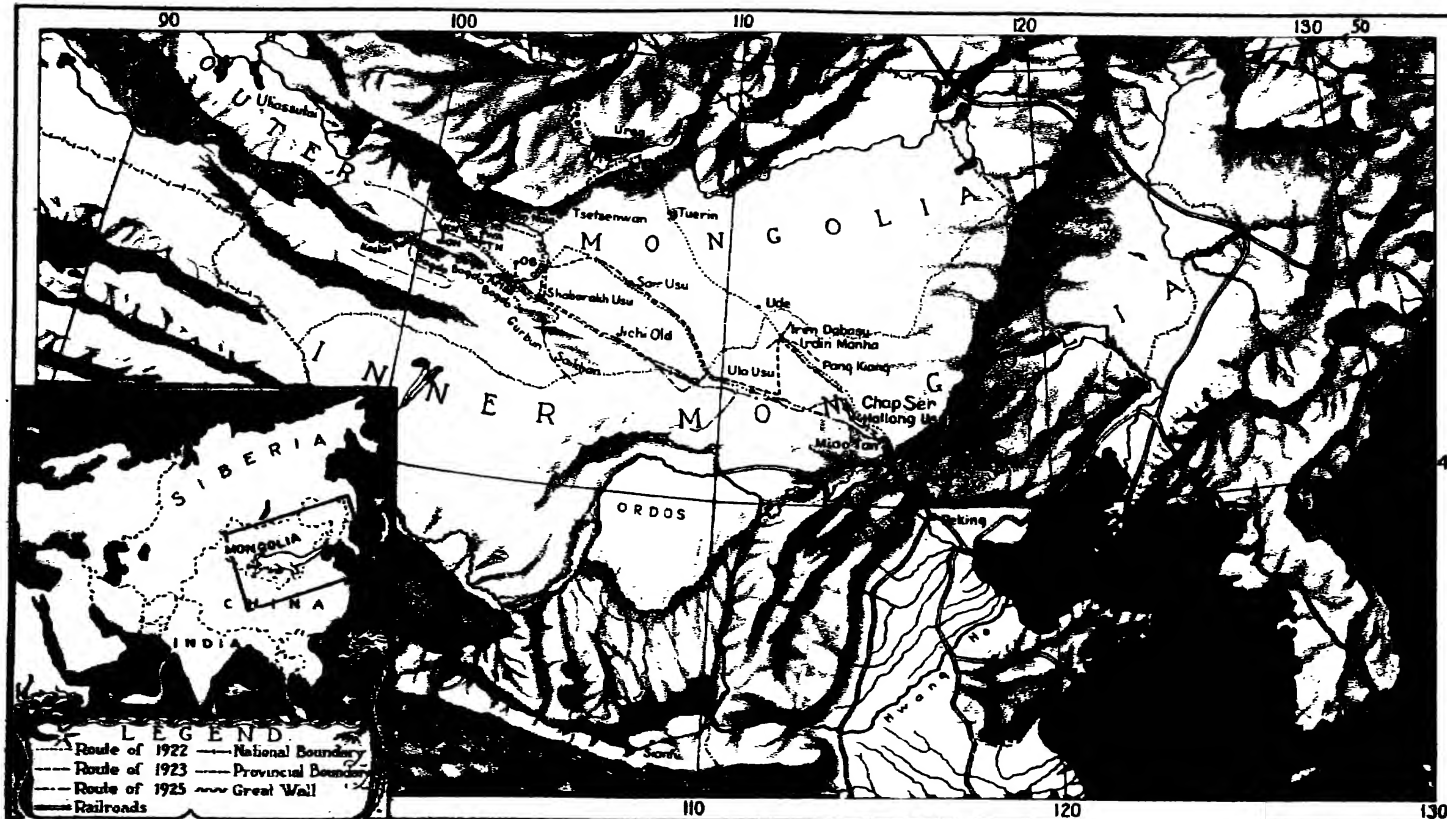


FIG. 1. MAP OF CENTRAL ASIA

THE MOUNTAINS ARE SHADED AS THOUGH THE LIGHT WERE FALLING FROM THE UPPER LEFT-HAND CORNER, WHILE THE BASINS ARE LEFT WHITE. THE MOUNTAIN RIM ENCLOSES THE MONGOLIAN BASIN SO THAT ALMOST NONE OF THE RIVERS REACH THE SEA. DURING PAST AGES SUCH INLAND-FLOWING RIVERS HAVE CARRIED DOWN TO THE CENTER OF THE BASIN THE SEDIMENTS IN WHICH THE FOSSILS ARE FOUND. DJADOKHTA IS AT SHABARAKH USU.

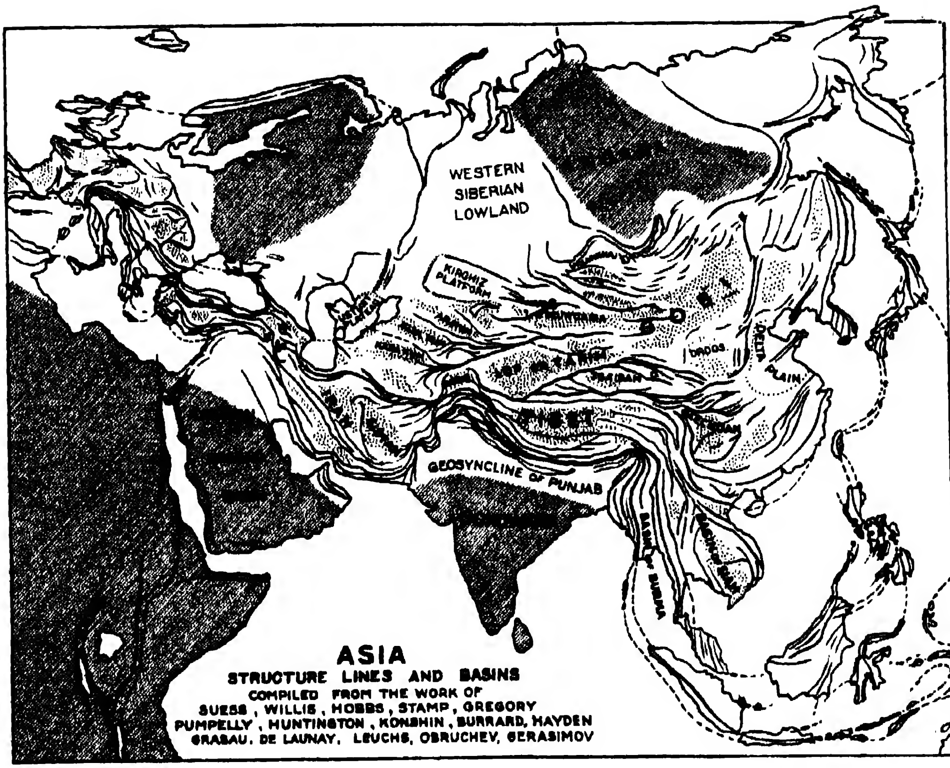


FIG. 5. MAP OF ASIA, SHOWING THE TREND OF MOUNTAIN RANGES, AND THE POSITION OF THE GREAT BASINS.

LARGE POSITIVE ELEMENTS ARE SHADED IN SLANTING LINES. THE GREAT STRUCTURAL BASINS ARE STIPPLED.

proached and the general surface is gradually levelled down into a "peneplane" or nearly flat surface. Whenever a new uplift occurs the old base level is changed and the forces of erosion begin to destroy the old peneplane and to build up a new one on a different level.

Drs. Berkey and Morris show that as the traveller proceeds from the "Arctic divide" in the Khangai Mountains in north-central Mongolia in a southeasterly direction toward Peking, he passes across five general levels in descending order. The highest is the "Arctic divide" and the remnants of the "Khangai peneplane," which is a broad, gently-rolling surface surmounted by low, rounded hard-rock hills or monadnocks: next comes the "Mongolian peneplane," which may prove to be a down-warped extension of the Khangai peneplane. Descending from the Mongolian peneplane one comes out upon the vast level floor of the "Gobi peneplane"; this is a surface of extraordinary smoothness which bevels the tilted and faulted strata of many geological ages. The geologists have not yet settled whether the planing force that produced the Gobi peneplane was blowing sand or whether the effect was the work of water in a past cycle of more humid condition.

In another communication Drs. Berkey and Morris point out that the Gobi peneplane is the easternmost of a series of great interior basins of Asia, including the Dzungaria, the Lop, the Balkash and Aral-Caspian and others, which are semi-arid steppe countries, including desert ranges, broad open minor basins

FIG. 2. DISTANT VIEW OF THE KHANGAI PENEPLANE.

THE FIGURE IS PART OF A LARGE FIELD SKETCH MADE NEAR SAIN NOIN KHAN, LOOKING NORTHWARD OVER TWO INTERVENING MOUNTAIN RIDGES TO THE ARCTIC DIVIDE, WHICH FORMS THE SKYLINE. THE PENEPLANE IS A BROAD, GENTLY-ROLLING SURFACE, ABOVE WHICH RISE LOW MONADNOCKS. SEVERAL GLACIAL CIRQUES ARE SEEN, BUT THE GLACIATION WAS NOT SEVERE.

and occasional depressions with lakes and salt pans. The Gobi has a width of roughly five hundred miles north and south and a length of one thousand miles east and west. The entire country from the southerly margin to the Arctic divide is warped into a broad open syncline, or gently-sloping concavity, whose central portion is three thousand feet lower than the outer margins. Thus the rims of the basin stand from five to seven thousand feet above the sea and the broad down-warped expanse between forms a basin-shaped plateau, parts of which are real desert.

The great basin of the Gobi contains many minor basins which the authors call "talas," from a Mongol word for an open steppe country. Thus we reach the fourth level from the top. Each tala, the explorers tell us, has its own local interior drainage and is bounded by inconspicuous warp divides or by mountain ranges, or both, separating it from neighboring areas of similar habit. Within each tala there are still smaller basins, called by the Mongols "gobis" and it is in these smaller gobis that the explorers discovered a great series of sedimentary formations representing many different horizons—from the Cretaceous beds containing the famous dinosaur eggs, at the bottom, through ascending levels of the Age of Mammals, containing many fossil remains of mammals, and culminating at the top in the loess deposits of glacial and post-glacial times. Thus we obtain the picture of a descending series of vast peneplanes and of basins within basins, the principal fossil-bearing strata being found in the lowest basins.

The Oldrock Floor and the Great Mongolian Bathylith

The fossil-bearing strata of the talas cover periods of millions of years in duration, yet they represent only the later stages in the history of Mongolia. Beneath the nearly horizontal sedimentary strata of the lowest talas, and in many other places where the later rocks have been cleared off by wind and water,

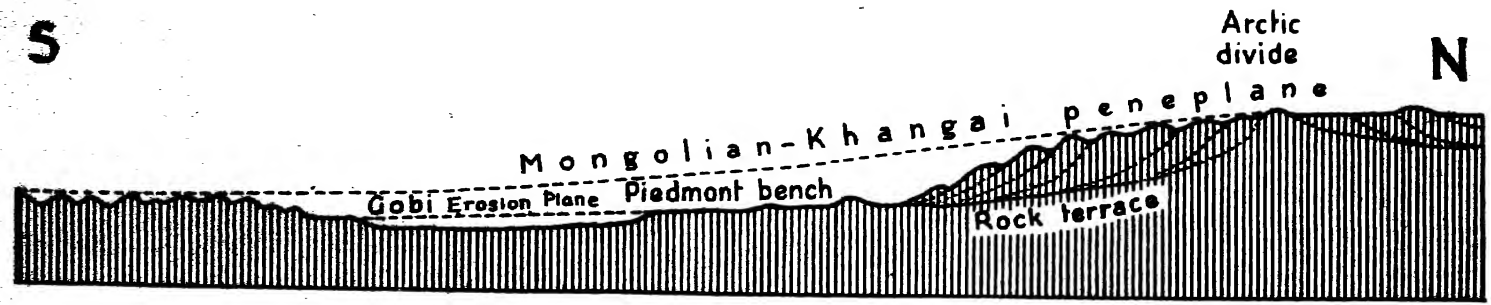


FIG. 3. RELATIONS OF THE PENEPLANES

DIAGRAM SHOWING THE KHANGAI PENEPLANE AT THE NORTH, WARPED DOWNWARD SO AS TO FORM THE MONGOLIAN PENEPLANE IN THE SOUTH.

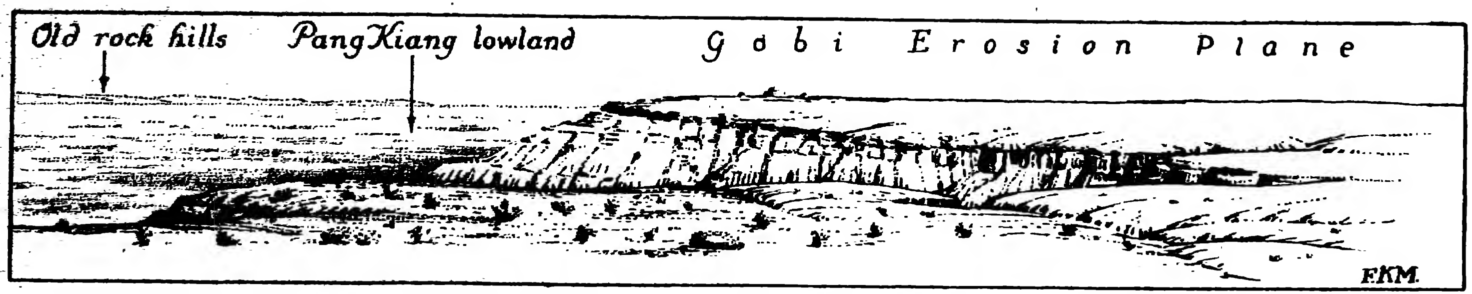
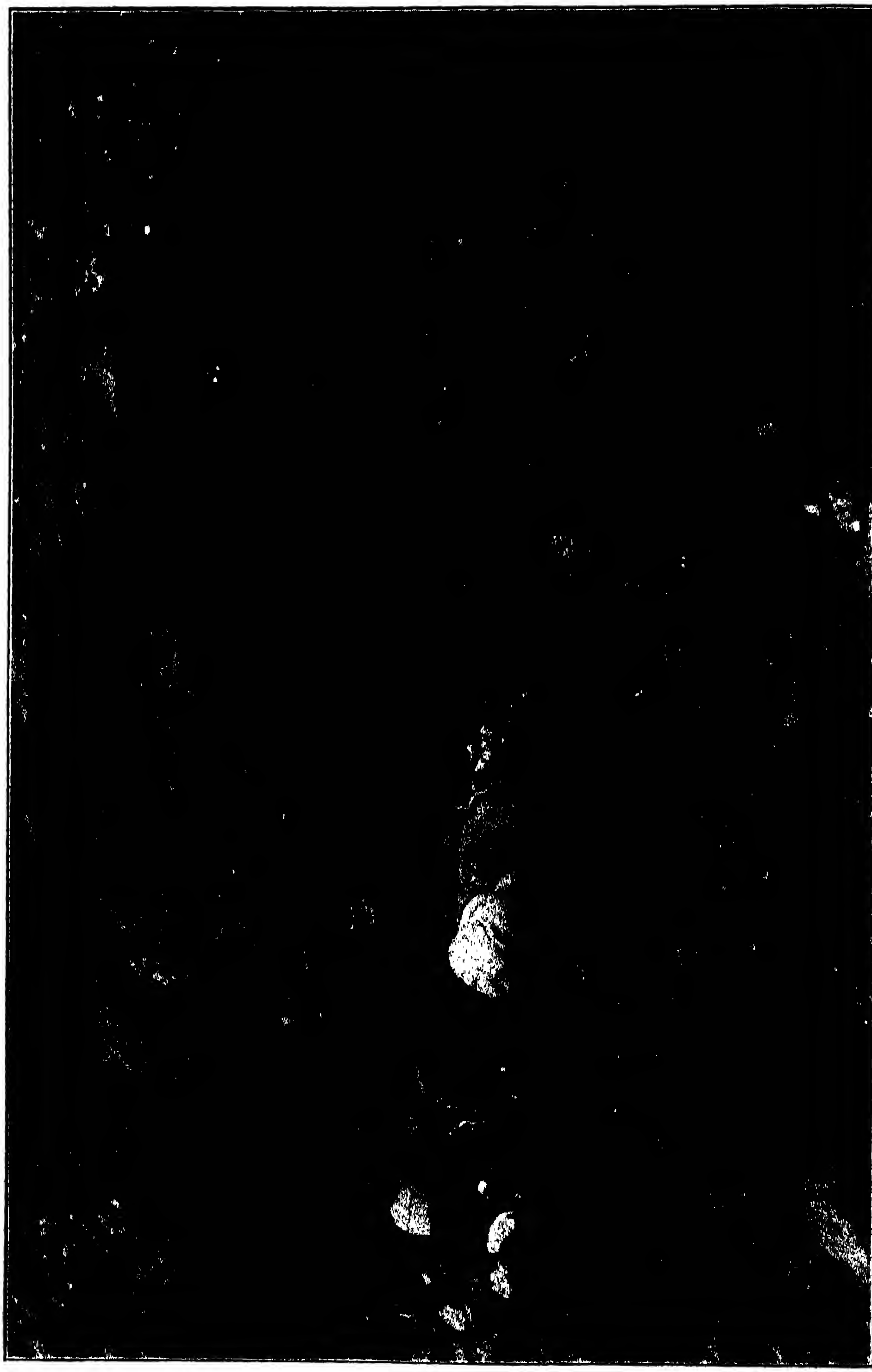


FIG. 4. FIELD SKETCH OF THE GOBI EROSION PLANE AT ARDYN OBO, LOOKING EASTWARD

THE SKETCH SHOWS: (1) THE REMARKABLY LEVEL SURFACE OF THE GOBI EROSION PLANE, BEVELING STRATA THAT ARE SENSIBLY HORIZONTAL; (2) THE LOWLAND OF THE PANG KIANG STAGE AT THE LEFT; (3) THE BADLAND BLUFFS DESCENDING ABOUT 300 FEET FROM THE GOBI UPLAND TO THE PANG KIANG LEVEL; (4) THE REMARKABLE SHORTNESS OF THE GULLIES OF THE DISSECTED ZONE, IN CONTRAST TO THE GREAT AREA OF THE PANG KIANG LOWLAND.



DINOSAUR EGGS WEATHERING OUT OF THE ROCKS

THE BLOCK OF SANDSTONE JUST BEHIND THE VISIBLE EGGS WAS QUARRIED OUT AND FOUND TO CONTAIN A COMPLETE NEST OF EGGS.

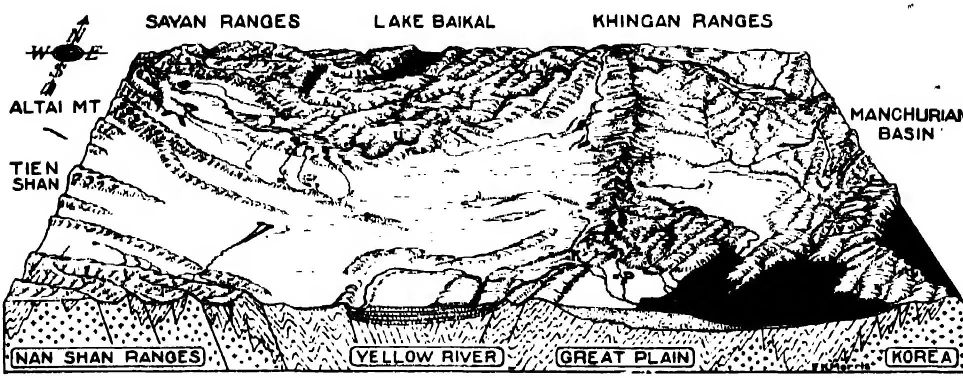


FIG. 6. PERSPECTIVE SKETCH OF MONGOLIA AND MANCHURIA.

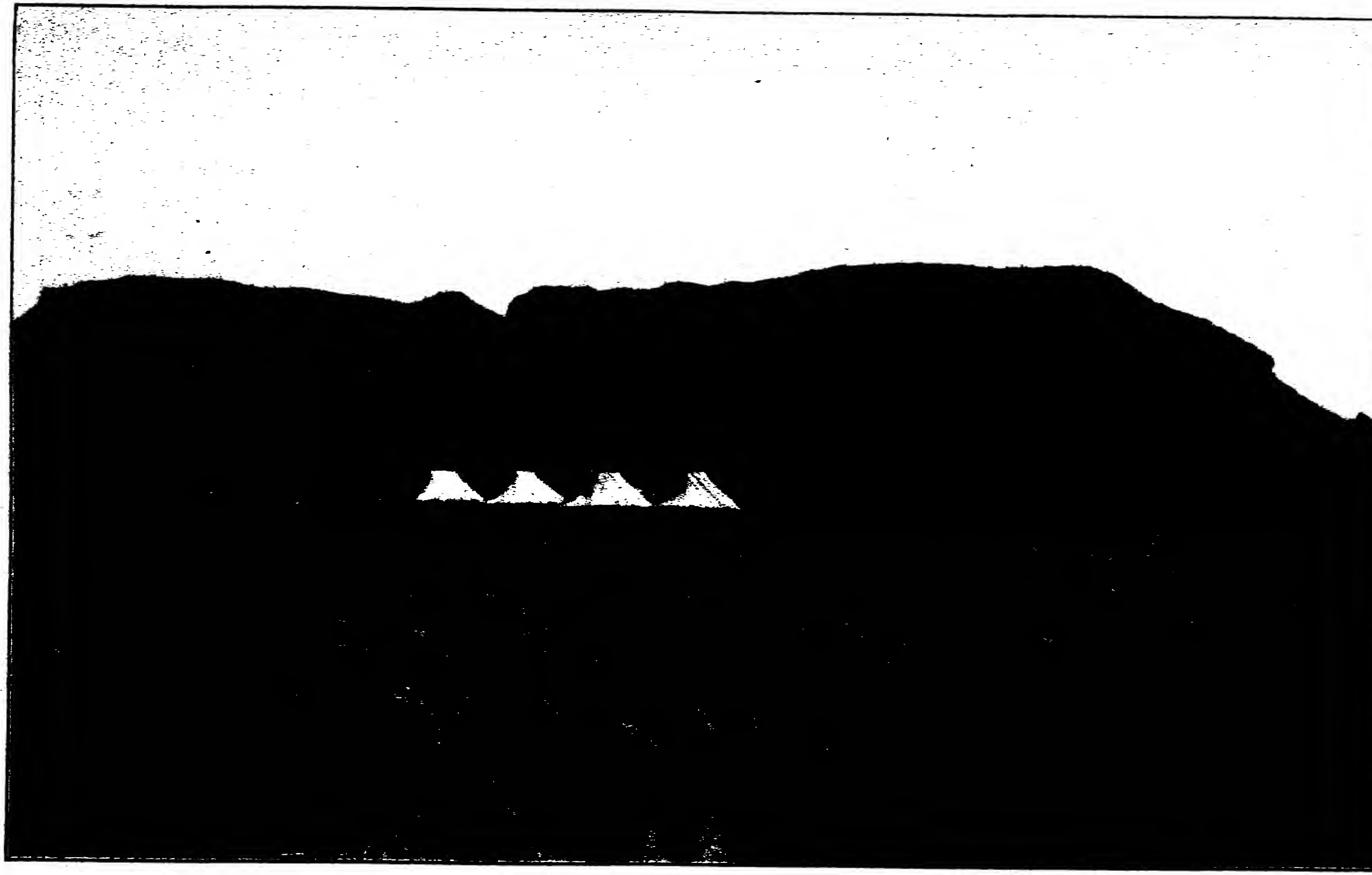
THE DRAWING REPRESENTS A BLOCK CUT OUT OF THE EARTH'S CRUST, SHOWING THE STRUCTURE OF THE ROCK FORMATIONS ALONG THE CUT EDGE. BOTH COUNTRIES ARE SHALLOW BASINS SURROUNDED BY MOUNTAINS. THE BASINS ARE SEPARATED BY THE GREAT KHINGAN RANGE, WHOSE STEEPER SLOPE IS TOWARD THE EAST. THE SEDIMENTS WHICH HAVE WASHED INTO THE MONGOLIAN BASIN IN LATE GEOLOGIC TIME CONTAIN THE FOSSILS OF CREATURES WHICH LIVED THERE WHILE THE SEDIMENTS WERE BEING DEPOSITED. THE LETTERS, P, K, U, STAND FOR PEKING, KALGAN, AND URGA RESPECTIVELY.

we find what the geologists call the "oldrock" floor of the great Gobi basin and the detailed study of this oldrock floor has revealed a picture of surpassing grandeur. All the millions of years represented by the rocks above the oldrock floor are as a watch in the night compared to the age of the oldest strata in the oldrock floor itself; all the warpings and deformations in the later rocks record only feeble stirrings of the vast plutonic forces beneath, compared with the terrific disturbances of the earth's crust testified by the presence of what the authors have named the "Great Mongolian Bathylith." This huge mass of granite underlies thousands of square miles in Mongolia. Its upwardly-growing roots penetrate the later rocks like writhing serpents of congealed fire. For millions of years after its first great outburst this immense reservoir of molten rock enjoyed occasional periods of rejuvenescence and at such times it played havoc with the older sedimentary rocks saturating them with its own living fire and often leaving them in a highly altered condition.

Naturally the geologists sought for evidence which would enable them to determine the relative age of the bathylith as compared with other rock systems of the oldrock floor and thus to assign it to its rightful place in the standard geologic column of rock formations. At a certain point in the oldrock floor of the Gobi desert, about one hundred and twenty miles southwest of Iren Dabasu, the geologists came upon a series of marine sedimentary beds containing invertebrate fossils. Professor Grabau later determined these fossils to be of Permian age, since they were specifically identical with fossils of known Permian age from China. In the same place the explorers noted an outcrop of granite, presumably from the Great Mongolian Bathylith, which appeared to be "faulted" against the Permian strata. From the fact that the Permian beds near the contact with the granite are not metamorphosed (as they would have been if they had been present when the granite was molten) and from the further circumstance that no dikes or offshoots from the granite were seen penetrating them, the geologists infer that at least in this region the granite is older than the Permian beds. On the other hand, the bathylith penetrates and undercuts the "Khangai graywacke-slate series" in the northern mountain area one hundred miles south-

CHIONJI BLUFFS AT DJADOKHTA

THEY CONSIST ALMOST WHOLLY OF FINE RED WIND-BLOWN SAND, IN WHICH THE DINOSAUR EGGS WERE FOUND.



RED MESA AT OSHIH

The cap is black basalt in which were found nuggets of agate which were used by prehistoric man to make stone implements. In the canyon below the camp the bones of the oldest dinosaurs of Mongolia were found.

UNEARTHING SKELETONS OF IGUANODONTS AT IREN DABASU.

west of Ugra and the graywackes are locally metamorphosed by contact with the granite over a wide territory. Hence the bathylith, at least in this phase, is younger than the graywackes. These in turn on various grounds are judged to be of late Proterozoic age. Thus the upper and lower limits of the age of the bathylith were determined, at least approximately.

As the graywackes and their associated beds of slates, jaspers and quartzites are older than the Great Mongolian Bathylith, so certain other components of the oldrock floor of the Gobi region are older by far than the graywackes. In some places a series of schists, phyllites, limestones, dolomites, quartzites and greenstones appear to represent the "Wu T'ai system" of China, which is classed as early Proterozoic in age, while a still older series of crystalline limestones, schists and complex injection-gneisses seem to be akin to the "T'ai Shan complex" of China, which represents the Archeozoic or Archean rocks of America and Europe. Great beds of conglomerate in these series are taken to indicate periods of emergence and rapid erosion.

Thus we see that the early history of Mongolia was broadly similar to that of other great land masses such as Europe and North America; that is, for tens of millions of years the land would be sunk beneath the sea and be deeply covered with marine deposits, then there would be long periods of emergence with great outbursts of granite and lava, the crumpling of strata into mountains and troughs, followed by deposition of epicontinental sediments and the slow process of peneplanation; then again the long cycle of subsidence and marine deposition, with subsequent uplift.

As noted above, all the rocks in the oldrock floor of the Gobi region are much folded over wide areas, but above the floor the warping and folding of later strata are but slight and local. Not since the middle of the Age of Reptiles did the sea flow over central Mongolia or drown its inhabitants in a great flood. The chief fossil-bearing formations of the Gobi desert are all of continental type and Mongolia for millions of years of its later history has been the secure home of many races of reptiles, mammals, perhaps even of the ancestors of man himself. From its windswept highlands it has sent forth its caravans and invading hordes in the Age of Mammals no less than in the days of Genghis Khan.

FORMATION OF THE MOON AND EARTH

By W. L. R. EMMET

THE GENERAL ELECTRIC COMPANY

THE idea that the markings on the moon's surface have resulted from impact of bodies drawn into it, rather than by volcanic action, has in recent years been advanced and discussed by various persons and there seems to be a growing tendency to belief in that theory. The author of this article wrote a paper on the subject in 1907 which may have been among the earlier discussions of the subject.

The purpose of this article is rather to discuss the conditions which might result from such action, and the inferences which might be drawn in the case of the earth and other planets, than to make an argument for this theory of upbuilding which may have been more completely stated by others. The appearance of the moon's surface can be studied by any one from photographs, or with a telescope of moderate power, and what is to be seen certainly affords basis for much thought as to conditions which could have created such contours and markings. If we can learn anything by such study it can be inferred that the knowledge has a degree of application to the earth and other planets.

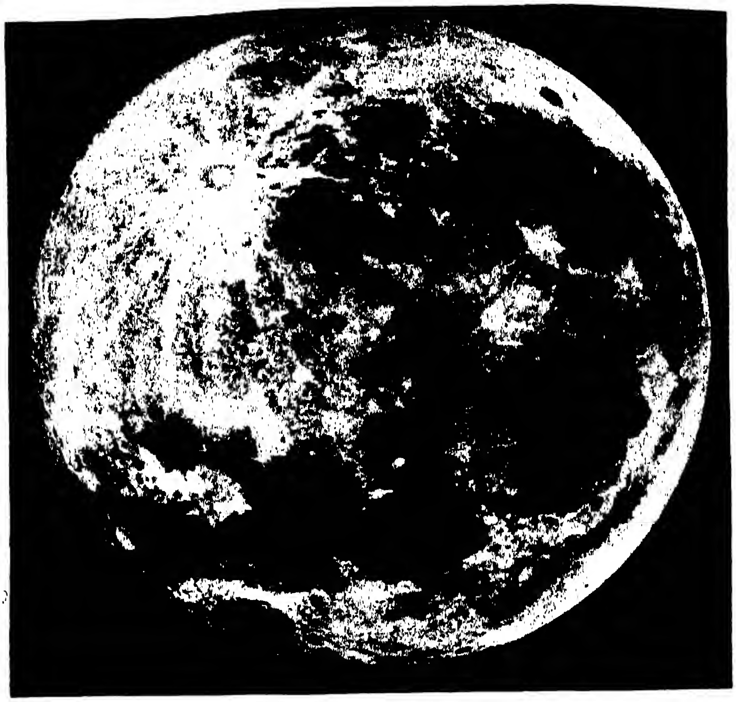
APPEARANCE OF THE MOON

The surface of the moon is covered with markings, most of which are circular or partly circular in form. The smaller of these markings have been generally spoken of as craters and the roughness of the moon's surface has generally been attributed to volcanic action. The smooth areas of the moon which have been called seas have also been attributed to extrusions of lava from the interior.

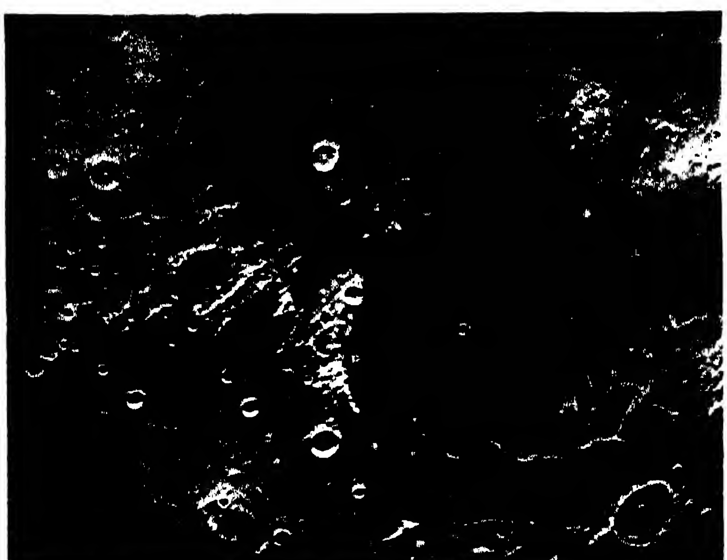
Even if we were disposed to believe that a molten moon would in cooling be subject to such vast and widespread volcanic activity, a view very far from that of the writer, there are various conditions which clearly show that many of these markings are not volcanic craters. In some cases two and even three of these circular markings overlap each other and their positions with relation to each other are arbitrary, while terrestrial volcanoes are confined to certain regions or lines of supposed weakness.

If the moon is looked at through a small telescope or a field glass its surface seems to be covered by areas of relatively dark and light color. An examination with a stronger glass of these darker areas will show that they are almost uniformly smooth in surface. Now, if we again use the weak glass and observe the general effect of these darker patches, it will be seen that their shape is either definitely circular or such as would be made up by the overlapping of several circles ranging in sizes from about 200 to 700 miles in diameter. These markings are somewhat confused and the circular form of many of their outlines is more noticeable in a slightly magnified view which does not show all the detail. In such a view the outlines, or partial outlines, of about ten circular areas can be perceived. The surface outside of these smooth areas is much broken and covered by hundreds of such circular pits.

The belief of the writer is that the moon's surface simply shows the record of its upbuilding through the entrance into it by gravity of thousands of bodies of various sizes. If we examine the



THE MOON AS SEEN THROUGH A SMALL TELESCOPE.



THE SURFACE OF THE MOON SHOWING THE PITS, WHOSE ORIGIN IS UNDER DISCUSSION.

moon with this idea in view and with reference to the probable sequence of events its surface shows just what might be expected.

Distribution of Matter in Solar System

The most generally accepted theory of the formation of the solar system is that the sun was at one time disrupted probably through tidal effects produced by some other body passing near to it. Such an occurrence might scatter its material in such a manner as would be necessary to the final upbuilding of the planets. In considering such an event we might imagine that the material would be widely and more or less uniformly distributed in a finely divided state, or that it would be thrown out in masses or in clots which might soon draw together by gravity into masses which might be hot from the original forces of disruption and from the heat of recombination.

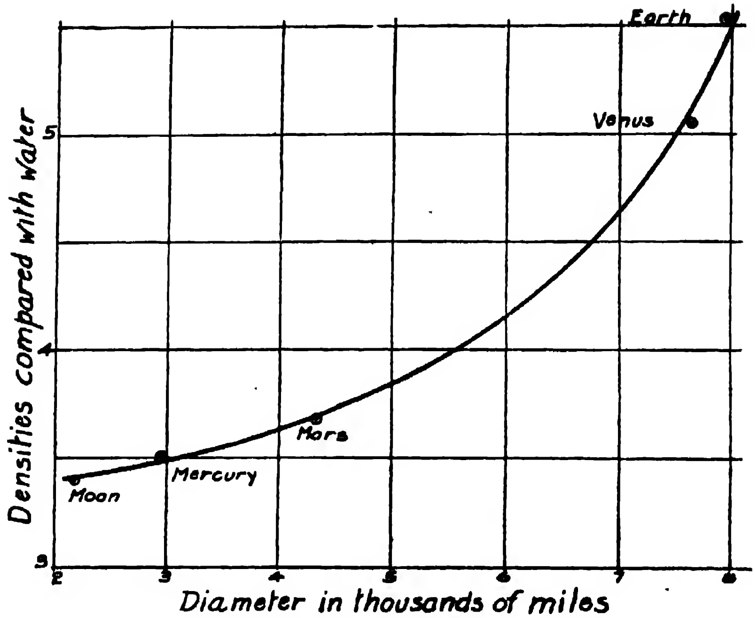
In the opinion of the writer this theory of scattering in masses is not tenable, and it seems much more probable that the material would be widely diffused and quite finely divided. In such an event the acceleration of no two parts would be exactly the same and the strength of material and its adhesion by gravity would be insufficient to hold it together in large masses. That there was not a completely uniform scattering of finely divided matter is evidenced by the fact that the orbits of planets are not circular, while the fact that they are nearly circular and in the average much more circular than those of the minor planets would indicate that the matter was much diffused.

The original motion received by any individual body in such an event could not be such as to give an orbital motion which was nearly circular. A circular orbit could only result from the combination of many bodies with orbits having various degrees of eccentricity. If any mass approaching the size of existing planets had been originally thrown off it would have had a highly eccentric orbital motion and would in a large measure have retained it. Thus the character of the orbits of the solar system may give us some clue to the nature of the upbuilding of the different bodies and the facts seem to give support to the general theory here suggested since the smaller bodies generally have more eccentric orbits. Most of the planetoids have very highly eccentric orbits. The eccentricity of Mercury is twelve times that of the earth and that of Mars five times that of the earth.

The surface of the moon gives an idea as to the early state of such scattered matter and indicates an order of upbuilding which seems quite consistent with the laws of physics.

In the early stages of such a process the space would be filled with many small bodies which would all move in orbits of various degrees of eccentricity. These small bodies would soon be cooled by radiation and would be drawn together by mutual attraction with small forces which would produce little heat when they came together. The larger bodies would capture smaller ones and would at first become overlaid with relatively loose material which would show circular pits where the different bodies had struck. Such a surface is seen on the rougher and more elevated portions of the moon's surface.

As time advanced many bodies in a given orbital zone would be subject to such accidental upbuilding and, as the smaller bodies were so taken up, the collisions would become less frequent, the space being occupied by a relatively small number of large bodies moving in orbits of less eccentricity. These large bodies would still continue to occasionally come together, but very long intervals of time would separate such meetings.



The largest member of the group would ultimately absorb all the others in its zone of action. As its body grew the matter entering it would produce more and more heat.

When the parent body became possibly a thousand or more miles in diameter bodies entering it and much of the material of the parent in region of entrance would be heated to fusion so that the place of entrance would flow to a level smooth surface composed of material presumably denser than the original material for the same reason that solidified lava is generally heavier than crystalline rock. After the formation of such smooth areas there would still be some small bodies free and some of these might be expected to ultimately fall into the smooth areas, making occasional pits in their surface as is seen on the moon. Such pits in the smooth areas show a uniform sharpness of outline and detail which might indicate relatively recent date of formation.

The surface of the moon, as has been stated, shows many such smooth lowlying areas. Some of them are definitely circular in form and others show outlines in part made up of the segments of circles. The moon also shows several prominent ridges which have the form of circular segments with the concave side steep, which presumably at one time formed part of the boundary of such areas of entrance.

There are other interesting features of the moon's surface which bear upon this theory. There are one or two places where spherical bodies have entered smooth areas, presumably before they were cooled to great depths, and have left only a faint circular ridge, and there are places where prominences have apparently partly been absorbed by fusion into molten matter below them. There is also a point on the moon's surface which has been named Tycho from which apparently solid matter has been scattered in definite radial lines as much as a thousand miles long, a phenomenon very difficult of comprehension but suggestive of an impact from without. Other features of the moon which are

significant in connection with this theory are its lack of atmosphere and its low density which will be discussed later.

Relationship of the Moon and Planets

If the moon had been built up in the manner outlined above it might be inferred that the planets had gone through similar conditions and that there should be found in the moon suggestions as to the probable history of our earth which might, or might not, conform to our knowledge of its present condition and past history as read from geological records.

An interesting fact as to the relationship of the planets to each other and to the moon is found in the densities as compared to the diameters of those of which the solid diameter is known. These relations are shown by the curve.

It will be observed that the densities and diameters come in the same order. If these densities are plotted against diameters it will be seen that they fall very close to a simple curve, further suggesting a rule of relation between size and density.

Since these bodies occupy various positions in the solar system, we might infer from this relation that the character of material distributed throughout the system was in the average nearly uniform and that the wide differences in densities of the bodies arose from the greater compression due to increased size, or to changes of material incident to this and the greater heat produced in the formation of the larger bodies.

These conditions can not be a matter of chance. The probabilities of simple conformity in order are 1 to 120, and the fact that these relations nearly conform to a rule of proportion as shown by curve practically excludes the possibility of chance, and by giving virtual proof of a relationship of size and density suggests conditions of matter under compression and heat very different from those with which we are familiar.

Our knowledge through experimentation of the compression of materials can only go to degrees corresponding to depths in the earth of thirty or forty miles, and we can have little knowledge concerning the effects of high temperature under high pressure conditions. Such experimental knowledge as we have of these conditions might not suggest the possibility of such differences as exist, but the fact that certain substances, of which phosphorus is an example, are known to be greatly changed by compression is highly significant in this connection. Great pressure and heat may have unknown relations to matter which may influence radio activity and changes of the elements. Whatever may be all the unknown causes of these differences of density, their conformity in sequence to the sizes is a highly significant and interesting fact, and it tends to give support to such a theory of upbuilding as has been outlined above. It would seem to indicate that the average of material is the same in all the bodies and that the difference is one of compression or some change resultant from heat and compression, both of which are dependent upon size. If the materials of the different bodies were appreciably different, this conformity in order of size and density would probably be interfered with. If separate large masses had been thrown off it might be expected that they came from different depths, or for some other reason might be of different material.

With such relations of condition in view, we might expect that the formation of the different planets was similar in character to that of the moon and that much might be learned concerning the upbuilding of the earth through examination of the many markings which we so clearly see on the face of the moon.

There are, however, very good reasons

why we should not expect to find conditions here on the earth at all like those of the moon. A body falling into the earth in its present condition will generate something like six times as much heat as it would if it fell into the moon, and even in the moon appearances would indicate that the heat was sufficient to fuse the body and much other material about the region of its entrance. The vast heat produced in the case of a body entering the earth would cause temperature conditions which it is difficult for us to imagine and which presumably have wrought great changes in the character of the earth's material, and which also have driven out gases which are now in part represented by its atmosphere and by the water of its oceans.

In the moon the heat of upbuilding being relatively small a vastly less proportion of the matter involved would be discharged as gas and the moon should have little atmosphere and little water on its surface. It should, however, be remembered that the almost complete absence of atmosphere and water on the moon may be more apparent than real. The lunar night being half a month long a very intense cold must develop by radiation soon after the sunset and this cold side of the moon will act as a great condenser to which the moisture will constantly recede from the surfaces heated by the rising sun.

Atmospheres of the Moon and Earth

There seems to be a good deal of uncertainty as to the quantity of atmosphere on the moon. From observations of the refraction or absence of refraction of stars passing behind the moon's edge it has been estimated that it could not be more than one four thousandth of the density of that of the earth. If it had the same quantity of atmosphere in proportion to its weight the ratio of densities would be about 1 to 24.

Pickering has observed various evidences of atmosphere on the moon and some doubt has been raised as to indications of refraction measurements under such conditions. Following the reasoning given above we might expect a very small atmosphere on the moon even if we do not assume that it has gradually lost its atmosphere, as has been thought probable by some students of the subject.

In the present state of the moon, with a night 250 hours long, the light side must be hot and intensely dry and the dark side very cold and presumably covered with snow. Such water as there may be is presumably seldom or never in a liquid state, being either suspended in the atmosphere in a highly expanded state or deposited as snow or frost crystals.

The nature of the action which may have caused the materials of which the earth was built to give up the water of the oceans and the gases of the atmosphere is probably very difficult for us to estimate, since it seems probable that the conditions which brought these changes about are far beyond the scope of our experimental possibilities, but we know that heat can drive quantities of water from various solid and crystalline substances.

If the accumulation of the earth's matter was as suggested above it was originally collected in a relatively cold state, all the small constituent parts having been cooled by radiation previous to their collection. Such loose collection of smaller bodies might involve substances in various forms of combination and capable of great change when subjected to great heat and compression. It is not difficult to account for the production of the water, carbonic acid and oxygen found on the earth since these might have been driven by heat from such materials as we find in the ancient crystalline rocks, but it seems less easy to account for the nitrogen. The only nitrogenous compounds which we know

have presumably drawn their nitrogen from the air. It is, however, reported that nitrogen is discharged from volcanoes and large quantities of it have come from certain deep well borings. It may have been present in the matter of which the earth was formed and have been completely expelled by heat from the rocks which we can observe near the surface of the earth. The relatively little heat generated in the formation of the moon might account for its production in much less quantity there.

Heat generated by Falling

If a body 500 miles in diameter made of such substance, for example, as granite were laid upon the surface of the earth without previous acceleration, its matter would sink into the earth; its parts falling an average distance of 250 miles. The heat generated would be sufficient to raise the temperature of such a quantity of granite about 8,000 deg. F. Such heat, however, would not all be delivered to the falling matter itself. A very large proportion of it would be generated in a large volume of earth material under and around the point of entrance and, since every part of the earth's mass would be moved to some degree, some of the heat would be distributed through the earth's material.

If such a body entered the earth by gravitation through the accident of orbital motion bringing them together the conditions would be very different, since the body would have a high velocity when it came in contact with the earth. This velocity would depend more or less upon the accident of relative motion. The marks on the surface of the moon indicate that the bodies have entered in directions nearly normal to the surface, which would indicate a considerably accelerated velocity, and it might be expected that bodies entering the moon or earth would enter with velocities corresponding to those of falling several thousand miles. If we assume that they have fallen into the moon from distances of 3,000 miles the degrees of heat which should be produced apparently agree approximately with the degree of fusion indicated by the appearance of the moon's surface. In the case of the earth the velocity of entering and the heat produced would be many times greater, but still it is believed that the superficial effect would be local, although other portions of the earth's surface would be much affected by the putting into the atmosphere of vast quantities of steam and gases.

The appearance of the surface of the moon would indicate that few, if any, of the bodies which had entered it exceeded 700 miles in diameter. The largest of the planetoids are thought to be not more than four hundred miles in diameter and it seems reasonable to assume that most or all of the bodies which may have come into our earth during the later ages of its life may not have been very large.

Growth of the Earth

Following such reasoning we would picture to ourselves an earth at one remote time similar in size, density and surface conditions to the present state of the moon. The space near the orbit of this smaller earth would be more or less occupied by bodies of various sizes, all operating in independent orbits with various degrees of eccentricity as in our present belt of planetoids. Each of these smaller bodies would be tending to sweep its orbital space clear of bodies smaller than itself.

From time to time, at longer and longer intervals, the orbits of some of these bodies being influenced by the earth and other planets would lead them into or near to the earth's path, so that the earth's attraction would cause them to fall into it. The relation of motion might be such that, instead of falling in, the smaller body would become a satellite and the satellites of the different

planets may be taken as examples of the unit of material of which the later growth of the planets was made up. The moon is presumably simply a large example of these which once operated as an independent planet and may have joined the earth at a relatively late period of its life. It now always faces the earth as Mercury is believed to face the sun. We might expect that they would both retain some part of the diurnal motion which they should once have had, but they have been situated as at present long enough for tidal forces to stop it, so that they hang in equilibrium like pendulums which have come to rest. Some lack of symmetry in their composition presumably contributes to this, and bodies built as we have imagined might be somewhat unsymmetrical, since the most heated portions might be of different density. Whether an unsymmetrical body would have more tendency to establish equilibrium under such conditions is not established but seems probable.

If we assume such a growth as the appearance of the moon's surface would suggest, we must conclude that later additions to its bulk were probably of diameters as large as from 500 to 700 miles and that their entrances were presumably separated by vast periods of time. During these periods complete stability would be established in the earth and organizations of life would presumably go on. Each of these periods would be terminated by a great change when some new body plunged into the earth's mass. To portions of the world not directly involved the effects of such an occurrence would be largely climatic. The diurnal period and the position of the poles might be slightly changed; great quantities of vapor and CO_2 gas would presumably be put into the atmosphere, geographical changes might greatly affect ocean currents and other conditions which influence climate. Changes of level would flood or drain portions of continental areas. Quantities of solid matter would presumably be thrown out by the effects of extreme heat near the surface but such effects would be local. From larger planets some matter might be thrown out with sufficient velocity to cause it to escape from the parent body and such actions might account for the comets and meteorites which inhabit our solar system, but which have no definite relation to the general plane of its rotary motion.

An interesting fact suggestive of this theory of meteorites is that they are composed largely of iron. The rocks of the earth contain large quantities of iron in chemical combination with other materials and it might be expected that very intense heating would drive off quantities of iron vapor. Since such discharges of metallic iron which were scattered on the earth or in its atmosphere would be rapidly corroded and absorbed by water and later deposited in sedimentary beds we might conceive that such conditions could explain large deposits of iron ore in certain places. Such deposits seem to suggest an origin very different from any present-day rock disintegrations.

It seems highly improbable that any such occurrence could destroy all the life on the earth. It might destroy all of some kinds of life but in most kinds of life, even on the land, there would be remnants which by seeking higher altitudes or other migrations could escape entire destruction.

The region where the new body entered would be completely fused and would fall to a low level and would invariably be covered by the ocean, so that such places can never be subject to our examination. Our continents are the parts of the earth's surface which have not been so hit in the more recent ages of its growth. Their material may be much the same as parts of the moon, except that erosion has removed the sur-

face to great depths and taken away all superficial signs.

Volcanoes and Earthquakes

It has generally been thought that the pits on the moon's surface were volcanic craters and that the moon had been the scene of extreme volcanic activity. The writer's belief is that the moon has never had a true volcano of appreciable size. If we follow the general assumptions as to conditions here outlined we might expect that volcanoes, earthquakes and also gradual changes of level and upheavals of mountain chains would result from the gradual cooling of hot masses of material at and under points where foreign bodies had entered the earth. Such cooling, which, due to the very slow rate of heat conduction, would extend through millions of years, would cause changes of volume and density which would cause gradual readjustments of level.

While the earth in its highly compressed condition shows evidences of great rigidity it is known to yield to relatively small pressures. It has been reported that stakes to which the Eskimo once tied their kyacks can be seen twenty feet below low water mark on the coast of Greenland, indicating that the ice cap a few miles thick is pressing the continent gradually into the sea. It is also known that in our last glacial period the ice caused depression of the region north of the Great Lakes and that it subsequently rose again after the ice had gone.

Such a cooling and shrinkage as is here imagined would presumably tend to cause cracks or lines of pressure release which would result in volcanic action. The interior of the earth is presumably made up of a variety of substances in places much heated, and held together only by pressure. Anything like a crack or vent in such places must result in volcanic discharge.

Theories have been propounded that the earth was once a uniformly heated molten mass which has gradually cooled to form a crust which through shrinkage of the interior is subject to occasional disturbances of the surface. Such a theory to the writer seems wholly untenable and utterly inconsistent with the fact that we have continental, elevated areas and vast depressed and relatively level ocean floors, and that we have volcanic action only in certain regions generally quite near the ocean.

There have been many other theories. One that the moon came out of the Pacific Ocean; another that the continents floated apart on a sea of molten material; another that ocean floors were made by outpourings of molten lava both here and in the moon. All these seem to the writer utterly inconsistent with the facts and with the laws of physics, while the general assumptions made in this paper seem to fit them pretty well.

Geological Record

The writer of this paper can not pretend to enough specific knowledge to form any very definite idea as to how this general theory may agree with the geological and paleontological record. To form a just opinion on such a subject would require much study and a careful separation of existing theory from established fact. Speaking generally it would appear that there is much in these records to support such a theory. It has been said by geologists that the world began its recorded history with a sparse atmosphere and relatively little water, and that it has been through a long succession of mountain elevations and subsequent levelings by erosion, of aridity and extreme precipitation, of tropical heat with a heavy carbon bearing atmosphere and of widespread glaciation. These wide changes from one condition to another have repeated themselves in many cycles from very early times, and descendants of the living creatures of one cycle have generally survived in a more or less changed form in the next.

Professor Lull has described a "Pulse of Life," showing that the evolution of new forms and the disappearance of

older types has generally conformed in time with these great physical changes in the earth and its atmosphere. Such conditions seem to agree pretty well with successive disturbances at very long intervals of time by such causes as have been here assumed.

In the writer's first paper on this subject, which is mentioned above, the idea was suggested that the world at that time, being smaller with a less force of gravity, might have accounted for the great size of some of the large dinosauria and for the fact that jumping was then in vogue among very large creatures, while it is now confined to relatively small ones. The evolution of flight was also mentioned in this paper and it was suggested that a lesser gravity, as well as a denser atmosphere, may have helped it. The evolution of flight under existing conditions seems inconceivable because a creature would require a very highly developed mechanism before the air could appreciably help it to overcome gravity.

If this theory of growth were correct, there would have been a change of size with these changes of condition. Whether such change of size might have been great enough to cause an appreciable change in gravity is a question which we should not attempt to answer without a very careful study of evidences and of the quantities involved.

The interesting fact in this connection is that all the marvelous changes in evolution have evidently been associated with very radical changes of condition. For such changes this theory of upbuilding alone seems to afford adequate explanation. What else could cause a symmetrically cooling earth to change from conditions of relative sterility with periods of glaciation to such a condition as is shown in the coal measures, and later to change back again to such conditions as are known in recent time? What could have produced the level and apparently homogeneous condition of the ocean beds and the smooth level areas on the moon which have been called oceans?

It would appear that all such phenomena might result from collisions of the earth with bodies of such size as are indicated by the markings on the face of the moon, or such as are known to now exist in the belt of planetoids and in the satellites of the various planets.

It must be borne in mind that the continental land bodies of the earth are by this theory the parts which have not been entered by bodies in relatively recent times. Otherwise they would not be continents but would be covered by the ocean. We should expect, however, that in very remote times these also have been hit by smaller bodies with less velocity and, although great quantities of material have been eroded from all surfaces, we might expect to find large areas in which the rock was of a newer and different character and that some of these areas might be found to be of a generally circular form.

The shape of ocean bed areas on the earth do not seem to indicate, as in the case of the moon, that they might have been formed by the entrance of spheres, but the covering of water would naturally greatly change the outlines, and a greater gravity with less degrees of elevation would make such markings less apparent.

There is one geographical feature on the earth which might suggest an origin similar to that of the partially circular ridges on the moon—that is the fact that the Aleutian Islands are arranged in an almost perfect circular arc—a strange fact, since nothing of the nature of a circle exists elsewhere in natural objects except for a definite reason. An investigation of conditions in that region might establish a relation between this fact and the theory stated in this paper.

The ideas and opinions here stated are not given as established truth but simply as suggestions as to reasons and relations which might justify careful study and comparison.

THE DETERMINATION OF SEX

By Dr. ROBERT T. HANCE

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

SEX, its various phenomena and particularly the possibility of its control or determination, has intrigued the human race apparently since the beginning of thought. Religions have been based upon it and innumerable attempts have been made to explain the why and wherefore of male and femaleness as well as to influence the proportion of the two sexes. There are now said to be over five hundred theories of sex determination, all of which have been additions to the hypothesis proposed by Drelincourt in the eighteenth century and put forth together with a review of what he termed two hundred and sixty-two "groundless hypotheses." As a subsequent writer pointed out, nothing was more certain than that Drelincourt's idea formed the two hundredth and sixty-third. So on down to the present day, man, able to control so many features of life, has constantly attempted to get at the basis of the fundamental phenomena of sex. As there are but two sexes the laws of chance will operate in favor of any theory 50 per cent. of the time and great things have been heralded by the proposers of various explanations deduced from isolated or selected instances.

In general two methods have been used in the more recent studies of the basis of sex differentiation, one being an analysis of the functional or physiological problems involved, the other being a study of the structural or morphological characteristics associated with sex. Under the first heading may be grouped all the experiments dealing with castration, with the secretion of the sex glands and their effects on other tissues, the chemistry of the sex cells and with the various attempts to regulate sex ratios. The morphologists concern themselves with studies of the microscopic anatomy of the two sexes and with experimental breeding. It is perhaps unfortunate that the members of one group have, as a rule, relatively little first-hand knowledge of the results obtained by those in the other field and *vice versa* with the consequent retardation of the achievement of the final solution. Although I may be open to a criticism of personal bias, it may be claimed that the morphologists in the past have perhaps erred less in this respect than have the physiologists. Happily the two groups are now finding their mutual information useful and are drawing more closely together.

Of the various physiological studies on sex that have been carried on those of Whitman and Riddle on pigeons are of outstanding interest. Sex, according to them, is a function of the metabolism of the egg; eggs with a comparatively high rate of metabolism develop into males, while females result from eggs of lower developmental energy. These modern observations are strikingly similar to the not uncommon conception of males being the product of a "strong" germ and the opposite sex arising from a "weaker" one. The physical and chemical condition of the egg seems to be a factor in the determination of sex, for maleness seems invariably to be associated with a high percentage of water and a rather low percentage of fat and phosphatides. The opposite conditions

are found in female-producing eggs. These results get considerable support from the studies of other workers on frogs and toads where it was found that (for frogs) when the eggs were overripe and a large amount of water had been absorbed by the egg before fertilization practically 100 per cent. males resulted, while the withdrawal of water from the eggs of toads before fertilization had occurred produces about 90 per cent. of females. Riddle has been able, by altering the physical conditions according to the observations outlined above, to reverse the sex of the egg and consequently that of the animal which would arise from it, which is an exceedingly impressive demonstration of the working out of his theories. Before, however, we further consider the more or less purely physiological account of sex determination let us see something of the morphologists' side of the story.

During the last thirty years an enormous amount of data has accumulated that indicates practically beyond question that the sex of the future animal is decided at the time the two germ cells unite. This is brought about by all the germ cells produced by one sex being alike, while those produced by the opposite sex are of two classes—male and female determining. When a male-determining cell unites with the neutral gamete of the other sex a male develops and *vice versa.* Sometimes it is the female that is monogametic (that is, produces but one type of germ cells) and again it is the male. The former case is, as far as known, much more common than the latter. Man, as an example, produces two kinds of sperm and but one kind of egg, while in birds the reverse is true, the female producing two kinds of eggs and the male only one type of sperm. Both the microscopical and the breeding evidence demonstrates this convincingly.

As the only connection between parents and offspring consists of the microscopic germ cells obviously all hereditary possibilities must be carried by them. In these cells are minute bodies known as chromosomes, which because they are the only obvious material in the germ cells that is contributed in equal quantities by both parents and because of the extraordinarily accurate mechanism that exists for its exact division and distribution to all the cells of the body, are believed to be the carriers of the hereditary characters. Some of the interesting features of the chromosomes are their constancy of number in a given species of plant or animal, and their constancy of shape, which, small though they are, makes the recognition of individual chromosomes within a species readily possible. Since sexually produced animals are the results of the union of two cells contributed by the father and the mother the chromosome contribution from each parent must theoretically be and actually is the same. Each parent has passed on half of the chromosomes found in the offspring and each one of these bodies that came from one parent has been shown, with the possible exception of the chromosome associated with sex, to have a counterpart or mate in the series of chromosomes that have come from the other parent. So all the chromosomes of the cell, like the fabled animals of the Ark, go in two by two. As constancy of chromosome number is a characteristic of species there must be some mechanism to control the number or else it would tend to double at each generation. This mechanism is found in the development of the germ cells where, before they become mature, the number of chromosomes is reduced to one half. Consequently, when egg and sperm, each possessing half the usual number of chromosomes, unite the entire number typical of the species results.

A most important clue to the importance of chromosomes was brought out

in the discovery in 1902 by Dr. C. E. McClung that male grasshoppers, during the period of the reduction of the chromosome number, produced two kinds of spermatozoa, one of which had one more chromosome than the other. Since these classes of sperm were produced in equal numbers it suggested some relation to sex and subsequent work substantiated the hypothesis. The females were found to produce only one kind of egg, all of which contained the same number of chromosomes. When the spermatozoon possessing the extra chromosome united with an egg the combination resulted in a female as the typical chromosome makeup of a female was produced. When, on the other hand, one of the second class of sperm, which lacked the extra body, mated with an egg a male was the outcome, as the chromosomal conditions associated with maleness were restored. In this particular instance the total number of chromosomes of the female was one more than that of the male.

The differentiation of the male and female determining germ cells occurs during their development or maturation. At this time the sex chromosome which, unlike the other chromosomes of the cell, is frequently without a mate, passes bodily into one of the daughter cells during one of the divisions that takes place in this process, leaving the other cell without a sex chromosome but containing all the others. The reduction of the chromosome number during germ cell development may be illustrated somewhat as follows:

A—the maternal and paternal chromosomes other than the one associated with sex.
X—the sex chromosome which is paired like the other chromosomes in the female but is single in the male.
O—the absence of a sex chromosome or of the mate of the sex chromosome in the male.

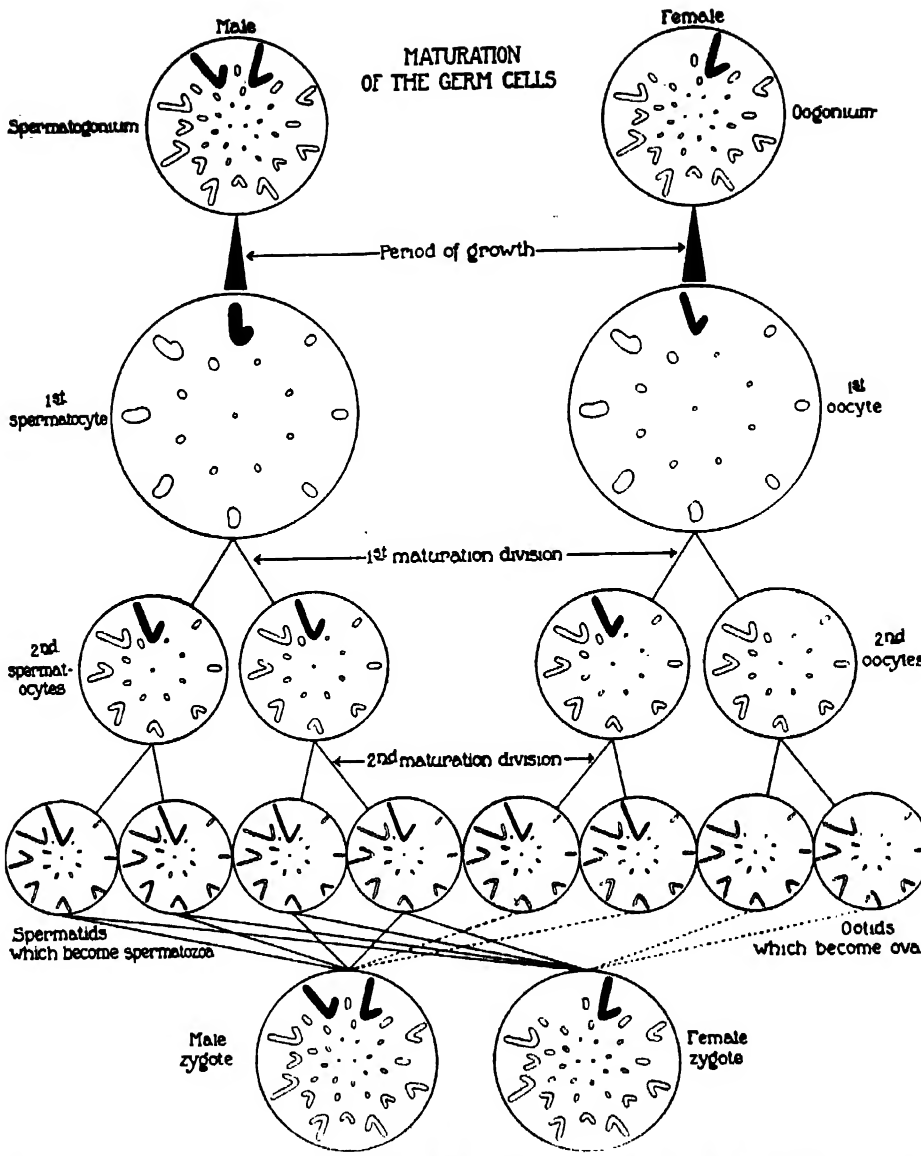
Full number of female chromosomes		Full number of male chromosomes
AA XX		AA XO
Reduced chromosome number of female-mature egg. A X	No. 1 — A X No. 2 — A O	Reduced chromosome number of male-mature sperm.

Union No. 1 produces—AA XX—female.
Union No. 2 produces—AA X0—male.

Femaleness is, in this example, associated with the cells of the animal containing two "X" or sex-chromosomes and maleness with but one. The morphological behavior of these so-called sex chromosomes has been found in complete accord with the mode of inheritance of such sex-linked characteristics as color blindness. This abnormality tends to be associated almost wholly with the male sex and to be transmitted through the daughters, who fail to show it, to their sons.

A similar situation regarding sex determination has been found in other animals, including man, *i.e.*, an odd chromosome associated with maleness and a pair of chromosomes with femaleness. In a few cases, although the principle is the same, the mechanism is reversed and it is the female that produces two kinds of eggs and the male but one type of sperm. The discovery of such cases has given very material support to the chromosome hypothesis of sex determination. The domestic fowl is the most recently studied form that falls into this class, and it has been found that in these birds the female has only one of a certain chromosome while the male has two. This results in two kinds of eggs and one type of sperm or just the opposite to the condition found in man and other forms.

The above account has sketchily outlined two broad fields of investigation on sex determination, the results of which



TEST-FIGURE 1. (Taken with slight modification from the *Journal of Morphology.*) A diagrammatic representation of the chromosomes of the domestic fowl in relation to the two sexes and to their behavior during the development or maturing of the germ cells. The small figures within the circles represent the chromosomes and those drawn in solid black are the ones considered to be associated with or directly instrumental in the determination of sex. The "cells" at the top of the diagram contain the chromosomes in full number as found in all the cells of the body and in the immature reproductive cells. Before they become functional as germ cells the chromosome number must be reduced to half as described in the text. It can be seen that, of the mature germ cells, the male cells or spermatids are all alike in possessing one black or sex chromosome while in the case of the female cells half have the black chromosome and the other half lack it. The possibilities of union are illustrated by the connecting lines. This diagram would fit the conditions known to exist in humans if the column of cells called "Male" be labeled "Female" and *vice versa.* In either case the principle is identical.

to date would seem quite antagonistic and are indeed so claimed by some. In the one case we find sex apparently controlled by certain obvious physical and chemical characteristics and in the other by a microscopic anatomical mechanism, the chromosome, whose behavior is so marvelously constant and which fits in so perfectly with genetic data. Which, if either, is right?

Certainly the evidence for the chromosome hypothesis, impressive though it is through furnishing a basis on which genetic results may be predicted, is still presumptive and is lacking in a genuine demonstration of the potency of these minute bodies. This possibly is less distressing to those who are best informed about the physical behavior of chromosomes than it is to the opponents of the theory. It has frequently seemed to the writer that these opponents have usually failed to recognize the fact that while the chromosome students must necessarily refer to the objects of their consideration as definite and visible entities, they have never lost sight of the fact that the chromosomes can not possibly act as units but only through the chemical possibilities they carry or even, from an extreme point of view, are the result of. While the evidence is strong for the maintenance of their individuality and constancy it is not unreasonable that a change in environment might cause a reaction in the chromosomes that would make itself obvious in hereditary alterations. It would be a brave cytologist who, with our present knowledge in mind, could think otherwise. Since the cytologists, because of their lack of any real knowledge of the subject, have generally neglected to stress their conceptions of the physiological behavior of the chromosomes, the physiologists have tended to underrate their probable importance. On the other hand, such work as Riddle's, carefully done and extensive as it is, will be the more satisfactory when the other side of the story of his pigeons—the chromosomes—is known.

Of interest in this respect are Dr. Riddle's[1] own views of the hypothetical place of the chromosomes in sex determination:

> The basic fact is that the two kinds of germs are differentiated by the degree or level of their metabolism. When either of these two kinds of germs is forced experimentally into the production of the opposite sex, the level of its metabolism is shifted to the level characteristic of the germs of the opposite sex. While the chromosomal correlation is here forced to failure the metabolic correlation here persists. The chromosomal constitution is not an efficient cause of sex; it is but a sign or index and possibly an assistance in the *normal* maintenance of that which is essential—namely, two different metabolic levels. But the requisite metabolic level of the germ may be established in the absence of the usual or appropriate chromosome complex, and the sex of the offspring made to correspond to the acquired grade or level of metabolism.

Doncaster[2] expresses the morphologists' beliefs in a way that differs from the above possibly only in the slightly greater importance assigned the chromosomes:

> The general conclusion would thus be that sex is dependent on a physiological condition of the organism, a condition depending on the interaction of certain chromosomes with the protoplasm of the cells, and therefore determined, in the absence of other disturbing factors, by the presence or absence of these particular chromosomes. If the difference between the chromosomes of the male and female is considerable, it will outweigh any other influences which might tend to affect the general result; every cell of the body will have either the male or female condition, and no external agency will be able to affect either

[1] Riddle, O. 1917. "The Theory of Sex as stated in Terms of Results of Studies on Pigeons," SCIENCE, XLVI, 19.

[2] Doncaster, L. 1914. "The Determination of Sex," Cambridge University Press, p. 144.

[3] Lipschütz, A. 1924. "The Internal Secretions of the Sex Glands." Williams and Wilkins Co., Baltimore.

the sex or the secondary sexual characters. This condition is especially characteristic of the Insects. When the difference between the chromosomes of the two sexes is less, but still sufficient to outweigh the effects of most environmental changes, the difference will usually be sufficient to turn the scale decisively to one sex or the other, but the secondary sexual characters will be less dependent on inherent differences in the tissues of the animals, and more on the influences exerted by the secretions of the sexual organs. This is the condition found in Birds and perhaps less markedly in Mammals. Finally, when the chromosome-differences between the sexes are still smaller, they will only be able by themselves to determine sex when no other causes influence the chromosome-protoplasm relation; if this relation is affected by other agencies, it becomes possible for an egg which would otherwise have been a female to develop into a male. This nearly evenly balanced condition is best known in the Amphibia, but there are indications that it is approached by some mammals.

We have reviewed the current opinions of the determination and control of the most important organic attribute—sex. One group of workers believe that maleness and femaleness are the result of the physiological condition of the egg, while the other group finds the sexes to be constantly associated with particular minute intercellular bodies, the chromosomes. The latter group agree that these particular chromosomes are concerned in some way with the physiology peculiar to the sex they are associated with, while the former believe that the physiology of the egg may at times counteract or in some way influence the function of the chromosomes. To the writer the chromosome hypothesis seems to be a bit better established, although the final conclusions may very well include the essential facts from both fields of investigation. In any case we find ourselves in the year 1926 still accepting the decisions of nature in regard to current sex ratios.

THE PASSING OF THE PROFESSOR

By DEAN OTTO HELLER

WASHINGTON UNIVERSITY

FROM the conning tower of eminent seniority I lately reconnoitered the academic field for the remains of that demolished institution, the college. Its site was marked by a disintegrating structure inclosed by a mixed assortment of decidedly new-looking buildings, composing a "general store" of knowledge called a university. The emporium teemed with young people, but most of them roamed about the premises like mere "window shoppers." In place of the old attachés one noticed a scurrying sales-force gowned uniformly in black brightened with the emblems of the various departments.

I concluded that the old professor had perished together with the old college. He passed out without pompous funeral, without necrologues, with hardly an obituary notice. I suspect an excess of absurd though not unkindly cartooning hastened his end. In self-defense against a world in flux he conformed himself to his caricature and became a fossil—which under dictionary definition means "an organic body so situated in its surroundings as to be capable of indefinite preservation." It availed him not. If the drop hollows the stone, how can a petrefact keep itself afloat on the deluge?

I

The modern college professor seems altered from the old pattern by something more radical than the imperceptible workings of evolution. He is apparently of quite a different make, normal and homogeneous in appearance and wholly devoid of that touch of freakishness which, after all, was an index of personality. Full regalia seem but to advertise him as a "quantity product" and do not cover up his family resemblance to those prouder cousins who do business on the Rialto. This explains the ardent admiration conceived by the Reverend William Sunday for the species. When, for his countless battles for the Lord and victories over Satan, that whirling Christian dervish was created a doctor of divinity by the University of Pennsylvania, he took one look at the galaxy of magnificoes and then, dropping on his knees, gave heartfelt praise to their Maker: "O Jesus, what a wonderful bunch of men!"

Go at the noon hour to the pastures of the Elks, the Moose, the Buffaloes, the Bulls and the Bears, and I defy you to spot the sporadic professor among his Loyal, Benevolent and Protective Brethren. Formerly he was alien to their lairs, now he is hail fellow well met there. They did not use to invite the "highbrow" in, for they felt uncomfortable in the company of literary aspirations. Nowadays, the bookish interests of the collegian run much the same way as theirs: to the volume of business. He frequently lectures to them—on the psychology of salesmanship, by preference, or gives inspirational talks, perchance on Christ as a Rotarian, or on the human side of retailing.

The townsman no longer shrinks from the encounter with the gownsman's portentous erudition. Pedantry is the least of the current professor's failings. He behaves quite like a plain citizen and can talk glibly on topics dear to Kiwanian hearts: the sporting page, the last quotations, the radio news, the golf

score, the *Saturday Evening Post*. He has even learned to desist habitually from that fastidious use of the mother tongue singled out by President Eliot as the unmistakable mark of the educated. Bad English comes as natural to him as to Mr. Theodore Dreiser, so that one is driven to repudiate the charge that this lack of refinement is merely assumed for protective coloration. Nor are the conversational tastes essentially different within the privacy of the set. Such things as literature, philosophy, art, science, music, the theater, are seldom seriously discussed save in pragmatical relations. Questions of a merely general connection, such as moral, philosophic, esthetic issues, are rarely aired among us. Unyielding controversy used to be carried on, in and out of our meetings, concerning educational matters of all sorts, broadly human as well as technical. Now we rarely grapple with the more fundamental problems. The agenda of our conventicles gravitate about dreary points of routine; deeper educational aspirations and anxieties are a private concern and as a rule remain a personal secret. The professor, singly, meets the most parlous moves—such as the fanatics' attempt on the life of science, or the boor war against the humanities—with the fortitude of bland indifference. Hence in the aggregate he becomes a silent and dangerous partner in the business of uneducation: master of the arts of acquiescence and doctor of the philosophy of *laissez-faire*. Or do we ever put up a counter-offensive against the impudence of the enemy, ever raise our voices in concert in behalf of good taste and civilized thinking? I ask, do we do that even under the stinging provocations of the Babbitts and the Bryans? The natural guess in reply to rhetorical questions like these is that in these times the college teacher himself may not be a developed specimen of cultured humanity. Environment and circumstances have made his mind business-like, matter-of-fact and almost closed to esthetic influences, while enthusiastically open to buncombe and balderdash.

The old-time professor was often categorically denounced on the outside as an "academic snob," not because he gave himself airs, but simply because he did not pretend to think and feel like a green-grocer or a manufacturer of chewing gum. To-day, a man afflicted with "aristocratic" proclivities does not have to step off the campus for his cure. We strive to please the crowd and capture its benevolence by imitation. Soon we become like our models.

The modern professor condones uncouthness in the undergraduate because he himself is ordinarily deficient in social graces and beset with angularity and crudeness. He cares nothing for deferential consideration from his students, because, it must be remembered, he was not drawn into the profession by any anticipation of social delights. Himself a product of the "new education," he can join in the popular rebellion against refinement without a sting of apostasy. Dignity demands reserve, and reserve goes with privacy; the live-wire professor has neither. He works amid bustle, and his spirit is in full rime with his environment. A barrage of typewriters, adding machines, card catalogues, filing cases and kindred paraphernalia of the educational industry does not protect him from constant trivial intrusion. Vendors of every time-payment commodity from encyclopedias to carpet sweepers and from canned music to group insurance stream unchecked into his sanctum and render his intellectual effort intermittent and desultory.

The rapid infiltration of business ideals has produced in our circles a new set of ambitions. As those conversant with the ways of the world academic know, a professor's standing in official favor, and his chances of advancement, are greatly promoted by his footing in

the community. Especially in urban universities the ideal "campus man" is likely to lose place to the better "mixer." The outside popularity of professors has great weight on the salary scale, and at some seats of learning its evidences are scrupulously booked and tabulated. While in earlier days a scholar was apt to be judged, not always wisely, by how much he published, he is now reversely appraised by the publicity he draws to himself. Last year the prize man of a certain faculty bagged thirty thousand agate lines from rural newspapers, largely as the result of indefatigable speech-making at Grangers' meetings and Teachers' Institutes. On the strength of this phenomenal "service" his salary was raised $250 at a single stroke.

These hectic activities do not alter the painful fact that the professorial chair as such functions as an insulator so far as important contacts go. Its occupant is compelled to channel his influence by indirection, through alien media. He is no longer a civic agent in the chemical, but only in the commercial, acceptation. As such, he has naturalized the vocabulary of high pressure salesmanship in his trade territory. The professor wants to make good, show results, sell his subject, deliver the goods. He joins lustily in the sloppiest slogans of commercialism and repudiates all claim to superiority over the hawkers of other wares; the more loudly he informs them that they are as good as he, the more they believe themselves very much better and treat him with marked condescension.

Far from mourning over the departure of his prestige, the professor hails it as a happy omen, for it betokens to his prophetic soul the "rising tide of democracy" and heralds the advent of the universal brotherhood of man. Now and then, to be sure, the brethren in the other walks inflict a chill on his *amour propre*. Instance a couple of recent experiences of my own. In our quad of a Sunday a gang of plasterers were breaking the Sabbath — quite gently, you may be sure—to the edifying ring of three dollars an hour. Maybe by the cut of my jib or, more likely, by the cut of my clothes, one of them guessed my humble station, and, seizing on me as pretext for an intermission, asked some questions about the business I am in. I told him among other things that the average college teacher needs a dozen years to fit himself for a job, and that for a similar period he "pulls down" less than fifty dollars a week. "This gets my goat," he condoled; "you fellers must be nuts."

And this I was told while on the road, incognito: "Take it from me, sir, everybody who's got any brains at all is after the almighty dollar—except them scholars and professors, I s'pose. But we've got over all that—there's nothing to it." It is consoling, after all, to be classed with the semi-intelligent, when one of our own order, writing last month in *The Nation*, declares us to be minus brains—and faith and courage to boot.

Now and then I meet some one who has "outgrown teaching," as he puts it with pardonable pride. Usually he is the holder of a high executive position, either in the scholastic industry, or in some more frankly utilitarian business. Invariably these converts, whether engineering some big educational establishment, or efficienceering a dry goods concern, consider the change a promotion. One of my former colleagues was thus beguiled by the voice of the charmer: "Come on, Prof. You're too smart for education. Take this job, and make a man of yourself." The "Prof" came on.

Thus, in sharply separated layers of society, little value is attached to the professor and his occupation. Even in the universities themselves those charged with administrative duties hold the favored places at the academic spread,

while the plain professor, the mere man of learning, sits below the salt, meekly playing his knife and fork without much friendly encouragement from those higher up.

II

For a moment let us dip into intramural sociology. As concerns the regents, or trustees, they are as a rule persons of great eminence in the business world, with hardly a bowing acquaintance with the corps of instruction. As they belong by virtue of their circumstances to a sphere that barely glances the academic orbit, there can be nothing invidious in their aloofness.

Heroically supersized in the community's vision, they hover abstractly above the stage of action, thickening into human shape on certain public occasions, but never getting down from the serene height of their *theologeion*. Sometimes they take an active interest in the financial welfare of the institution under their control. To the personnel they do not have to devote much care, if any at all. In privately endowed schools they are usually selected for their ability to contribute liberally to the funds. In many cases they justify the speculation beyond the dreams of avarice; sometimes, though, they do not come across handsomely, and enjoy the honor without giving any return. From the degrading influence of the lowbrow politician at any rate this class of institution is almost entirely free. In state universities and "land grant" colleges, the regents are appointed mainly for political reasons and occasionally given to crude persistence that the university shall give the taxpayer what he wants.

The recent enormous aggrandizement of the college president, as evidenced, for example, by his pompous installation in office, I do not presume to explain. Not so long ago, the president sat, so to speak, on the same platform with the faculty, and his superiority was secured chiefly by spontaneous respect for his stature. To-day the president is not necessarily the biggest man in point of insight and inspiration. Consequently, the distance between the academic body and its head has been stretched in some artificial fashion to give him a semblance of majesty. This could not be accomplished without pushing his authority also to the peak, until his word is law within his domain and well-nigh gospel without. Layman and collegian alike magnify him until he accepts himself at the fantastic value suggested by their homage. Is there any wonder, then, that this adulation has tended to make him arbitrary and dictatorial? At first, indeed, the apotheosis of the president completely turned the heads of some newcomers to the office. *Delirant reges plectuntur Achivi.* A sudden reign of terror threatened to decimate the professorial ranks, and no lives were safe as duodecimo Mussolinis, like the rough-and-ready Benton of Vermont and Ayers of Cincinnati, laid ferociously about them to infuse new life into their schools by a massacre of the teachers. But the treat-'em-rough method of university administration so reduced the attractiveness of the profession that, almost literally, the supply threatened to run out. That was twenty, thirty years ago. The executive attitude that now obtains wisely takes the shortage of man-power into account; consequently, under the newer dispensation the professor is secure enough in his tenure so long as he pulls his load in bridle-wise fashion and does not kick over the traces. In the American university of to-day acceptance of the régime comes before loyalty to the institution and to the cause of learning. Open criticism of the president is lèse majesté and mutiny. There is of course very little of that, and the average professor holds back with any opinions that

might antagonize the "administration." It is a humiliating comment on the energy and initiative of our faculties that with us changes in education, beneficial or otherwise, are largely the work of determined presidents, whereas throughout Europe they are inaugurated by the teaching force. A *ben trovato* incident epitomizes the difference. During his term as rector of Berlin University, the great theologian, Adolf Harnack, is said to have presented President Wheeler, of the University of California, to the German Emperor with this speech: "Will Your Majesty graciously receive our distinguished guest from the United States. He fitly bears the title of 'Exchange Professor,' since he comes from a monarchy within a republic to a republic within a monarchy." That this monarchic form of government moreover leans heavily toward absolutism is chiefly the fault of the governed. The disunion of the teaching force, its lack of parliamentary sense and its disposition to let issues be swamped by details and causes by personal animosities, make a return to republican governance undesirable while the professor's nature remains as it is. It almost looks as if a much greater centralization of authority might be needful to save the "higher" education —which just now justifies its name by being all up in the air. The titular address of a university president abroad is "Your Magnificence." In this country we may yet come to address him as "Your Omnipotence," without further detriment to the cause of education.

The university president's compulsory intercourse with wealth and power inescapably affects his mode of living and, under Veblen's theory of the "Leisure Class," involves him in pecuniary emulation. In the halcyon days of the McCoshs, Gilmans and Eliots this tendency was inchoate, and the presidential ménage was not markedly different from the professorial. They held to the same standards of dignified and by no means inelegant simplicity. Therefore the president was seldom paid even twice the regular professor's salary. Owing to the high cost of social importance to-day the disparity of the two types of pay is so great as to place the president and the professor on opposite economic and social footings; the one is merged in the mass, while the other dwells apart in regal grandeur.

I am not making a special point here of the professor's notorious impecuniosity. On the whole, he is better off, not worse, than was his predecessor. And in announcing the latter's demise, I did not blame his death on starvation. He was neither gourmand, nor gourmet, and all his tastes were frugal. In his raiment he was averse to splendor, if not always to shine. Yet he was not without his comforts and special luxuries. He indulged in a good concert now and then and in a high-class play, in course of time accumulated a fine collection of books and once in a while contrived a trip to Europe. The luxuries of conspicuous living which were beyond his reach he happened not to covet. So he got along on very little, yet maintained a high degree of social dignity in all relations. Far from grouching over his lot and his labors, he considered himself generously compensated by his position of honor in the minds of the people. True, he may have reasoned himself into this happy peace of mind by such romantic arguments as brightened Bishop F. D. Leete's pastoral message to a recent Methodist Conference: "The time has come"—quoting the right reverend gentleman literally—"when ministers are paid as well as the average layman, for their pay includes opportunity for intellectual improvement, possibilities for desirable friendship with God, and the gratifications that come to those who render spiritual aid." Or he may have remembered Plato's more original prescript for the

elect: "As for gold and silver, we must tell them that they are in perpetual possession of a divine species of the precious metals placed in their souls by the gods themselves and therefore have no need of the earthly one." Anyway, the peace of mind was there and in conjunction with the professor's temperate habits conduced to such a lengthening of life that in the eyes of Messrs. Andrew Carnegie and Henry S. Pritchett professorial longevity presented a grave educational problem. For which reason they persuaded Alma Mater to wean that overgrown child from her breast before a possible lapse into second infancy, and for the sequel relied on the lethiferous effect of unemployment doles. The well-hecked scheme foundered on the pensioner's tenacity of life and his ability to subsist on hopes, ideals and kindred inedibles. Progressively the rations were attenuated, to no avail. The trimming down of the Carnegie stipends appears to have been a standing order of business and possibly something of a standing joke, too, between the Laird of Skibo and his Grand Almoner, for the more the pension was enlarged upon in reports and circulars, the smaller it became. And still the old prof stubbornly held on and refused to pay his debt to nature. In sheer despair at being unable to kill him off, they lastly killed his pension. Even after that he stuck it out a little longer. And never a complaint did he utter. "The Laird giveth, and the Laird taketh away. Blessed be the name of the Laird." Dear old soul!

The lesson of it is, you may separate a professor from his provender, but you can't starve him to death. And so he has to be led to heaven through another gate. The experiment under way is that of working him, or making him work himself, to death. He willingly submitted to the experiment, after swallowing the superstitious story about the American business man working fifty weeks in the year, six days in the week, and eight hours in the day, and taking with alacrity the hint that it was incumbent on the American scholar to behave like the American business man. In theory the "teaching load" in the colleges has not been increased, but in actual practice a professor, if his lines be cast in the academic hinterland, almost doubles his schedule in supplementing his revenue by teaching in summer schools, Saturday schools, night schools, correspondence schools, thus acting as gun-bearer to the devil in his devastating pursuit of scholarship. In very many cases a university teacher in the professional branches adds permanent or casual outside jobs to his scholastic duties. Yet it must be said in his favor that none of his multifarious tasks are taken lightly, and that he is held by his inherited conscience to a generous discharge of all his duties. How soon under such a burden he will wear himself out is still an experimental question. In the meantime, sixty-five is the official *nec plus ultra* for the professor, while no statute of limitation is set upon the service age of trustees. Perhaps their reserve store of vitamins is deemed a guarantee against senility. Or is, perchance, no brainwork required of them?

Out in one of the Ohio road colleges the trustees perpetrated a grim joke on themselves, by account of a recent novel. The ablest man of the teaching force, having reached the retiring age while still in perfect physical and mental condition and being greatly in need of the income, petitioned for a prolongation of tenure. No, sir, said the trustees. We are sorry for you, but you are too old to teach. Your mind has lost edge for any real intellectual exertion. However, in recognition of your past usefulness to our beloved institution and to retain you in her service, we have elected you a life member of this board.

I repeat that I can not regard the salary question as the crux of the profes-

sor's social predicament. True enough, he did find himself in a sad economic plight during the war and right after. But since then a nation-wide support of his demand has borne fruit so that, under a bettered wage scale, he may brave the responsibilities of marriage in his middle forties and in his fifties may even contemplate paternity. Yet for the needs of dignified family life our salaries are still far from adequate. I am unwilling to concede that a competent university teacher should travel through life with a lighter purse than a public official of corresponding accomplishment—say a circuit judge; their salaries ought to be equalized, that is, after the judge gets "boosted" to $10,000. In truth, the $10,000 professor is already on his way to school, and in a few places he has actually arrived. Those men are properly paid because they are, or are supposed to be, objects of competition between school and industry or between rival schools, or to have a choice between professing and practicing their knowledge. At all events, these few have raised the standards for their class in several important ways. Impoverished, labor-driven and humiliated educators can not function to much effect as factors of public enlightenment.

III

I am far from arguing that our confrèrie is to be charged with civic indolence. We work rather overtime for the public good. The professor is a fast and zealous "joiner." He pays his full dues in time and money to social, scientific and philanthropic organizations, hobnobs with the politicians and belongs to most of the up-and-doing blatherbunds. In these connections he generously does his chores, but contributes sparingly of his ideas. He knows that the true purpose of higher education is esoteric and can not be openly avowed in a democracy. It consists in steering the gifted minority from the crowd. The up-to-date educator, however, follows on the heels of the crowd, and instead of heading the people for the light, he only quickens their step in their set direction. He has made himself less and less distinct from the crowd and in the end achieved a total lack of distinction.

The painful fact is that in making himself safe for democracy, he has slid down from the upper stratum of society almost to the bottom of the middle class. One commencement orator this year, descanting on the marvelous equality of all Americans in respect of opportunity, naïvely hinted the depth of this fall. Anybody, said he, may become president, "from the highest magnate to the pariah, from the cabinet officer to the college professor." The professor's station in society may seem in itself a matter of indifference, yet there was public as well as personal benefit in the prestige that was his. It brought home to him a gratifying sense of the value of his work. And it was the fountain-head of his influence.

Without demonstrating at further length the social decline of the professorial class, I am prepared to venture a guess that there is no strong desire for change in our *ensemble*. It may seem singular that it should have been reserved for a college president to put his finger with precision on the sore point: "Until class consciousness extends throughout the teaching body," says Dr. McCracken, of Vassar, "the democracy of control will hardly include the professor." Now class consciousness in the last analysis is a feeling of pride in the superiority of one's group to other groups. It is not enough to consider ourselves no worse than other people, we must again learn to consider ourselves better than most of them. "So long as we are no better," says Professor H. R. Mussey in an article of recent issue, "so long the colleges will be no better than the schools and the churches and the trade unions and the women's clubs and

the athletic associations and the chambers of commerce and the sons of deceased patriots and the loyal orders of associated tombstone manufacturers that make up our everyday America."

IV

Now the economic discomfort, loss of caste and shrinkage in self-respect under which our profession labors may plausibly be referred to one and the same cause, namely, to the ominous public indifference toward the so-called higher education. Again it is possible to validate this opinion by means of presidential testimony. Within a half year or so, I have heard no less than three of our leading college presidents avow almost publicly their belief that the American folk do not really love education and are not really a culture-loving people. It would be a miracle indeed if a public that looks for spiritual ministrations to a Billy Sunday and a W. J. Bryan could be seriously interested in the selective breeding of intellects which, when all is said and done, is the chief office of higher education. A higher education ordered by middling-to-low intelligences remains forever a contradiction in terms. Its control can not be committed to the general suffrage, it belongs by right of reason to the enlightened elect. The presupposition upon which the life of the university is founded is reverence for scholarship, irrespective of its utility and popular appeal, and a voluntary subordination of the average mind to a superior grade of mentality. The reverse relation is responsible for our shallow national percipience. Only through soul-searing abatements from hallowed conviction and sacrifice of principles could a collegian of the old school survive under an educational dispensation which lethargically connives at the downgrade trend of culture. There's no need of mincing words where even college presidents speak out frankly. The general course of the country is set against the concerns of culture, and the educational policies are warped to the dominant tendencies of the age. Democracy seems bent on vulgarizing education, and the great Moloch of business, too, is at work preparing education for its Gargantuan taste and appetite. The numerical mania has taken a grip on the university. *Intra! Salvere jubemus,* we salute youth from our portals. Why frighten the entrant with Latin? Let us say in plain English, "Pay as you enter." The main question is not how good is our show, or how select the audience, but how many are willing to pay the price of admission. After making the limits of freshman enrollment coextensive with the birth-rate of seventeen years before matriculation, we are trying our utmost to please our pay-guests so as to induce them to stay. The college to-day, says one of our most enlightened presidents, exists to give the student a happy life. It is wrought in the image of the undergraduate.

It follows logically that in these circumstances it behooves the professor to become a true reflex of the same image. It serves him better to be a good scout than a good scholar. The "popular prof" is not he who makes a bold stand for scholarship but he who comes nearest to the pragmatic standards of the populace as refracted through the student body; consequently, the young instructor who looks after the main chance is more likely to imitate his sophomore students than his senior professors. The rapid augmentation of the teaching force, due to the abnormally multiplied attendance, has done its share to dispel the professorial aura, and so, too, has the ranging of the academic business into all sorts of profitable side lines. No halo of great learning surrounds professors of advertising, embalming and cheer-leading. And inasmuch as to the layman a chair of milking looks no higher than a milking stool, he naturally

has the same esteem for our contemporary Jameses, Whitneys and Newcomes as for practitioners of the aforementioned arts and sciences.

V

One can only wonder that in the face of all these discouragements persons of marked ability do still espouse this calling. For undeniably the new college teacher is as "competent" as the old; often more so in specialized vocational knowledge, as he is likely to have wasted less time on "mere literature" and such frills.

Nevertheless, the supply of able-minded recruits for the profession is not in keeping with the great demand. Although the development of graduate schools promises to provide plenty of teachers, the number of first-rate men whose undergraduate curriculum is shaped with an aim to teaching, and who enter the graduate school properly prepared, is negligible. The recognition of the latent danger of this situation was the mainspring of certain large-featured enterprises for the improvement of the professorial fortunes. Sometimes they merely plan for the increase of salaries, as when a John D. Rockefeller sets fifty million dollars as a bait to lure the quadruple amount into the trap for that specific purpose. Sometimes, on the other hand, the concern for the material sustenance of the profession and for its social dignity is explicitly coupled with the ulterior care for the propagation of science. The most striking example is furnished by the Carnegie Foundation for the Advancement of Teaching.

The very name clearly shows that the ulterior aim of this foundation went beyond assisting the professor in his valiant struggle with poverty. At the same time, the teacher was recognized as the most vital factor in the advancement of teaching; hence this foundation at first addressed its efforts to the invigoration of the teaching force through timely superannuation of the invalid and the time-worn. Also it was expected that by liberal protection a superior class of persons would be attracted to the profession, for it was thought essential that faculties should be made up of those richly endowed in culture and intellect. Thus the foundation hoped to avert what has, alas, by now befallen—namely, the rebuilding of Academe into a "Temple of Mediocrity." Unquestionably, improvements ensued upon the foundation, mainly through the raising of standards —for the time being, at least—as a preliminary for admission to its benefits. Whether permanent improvement came *propter hoc*, or merely *post hoc* need not be gone into here. While many people attribute the credit to Mr. Carnegie's munificence and Dr. Pritchett's far-sighted educational statesmanship, others will side with President McCracken's opinion that the process was inevitable and would have come about quite independently of that influence.

At all events, the expansion of its scope and the assumption of varied and expensive functions led gradually from a chronic reduction of the annuities to their sweeping abolition, and in the end to the institution of an insurance plan in lieu of the original system of pensioning. President Pritchett and his board found a rational sanction for their altered course in their stated conviction that the pension system was selfishly exploited both by institutions and individuals. Having dismissed the professorial tribe from his paternal solicitude, Dr. Pritchett eventually confessed the opinion that private donations for any educational purpose are questionable. It is no far cry thence to the conclusion that all charity should begin at home, and better stop right there.

Whether the foundation has missed its unprecedented opportunity to lift higher education permanently to a significantly higher plane, it is too early to decide. So far, its visible effect on education has

been mixed: good mainly in that it drove some too patently inferior colleges out of business; bad mainly in that it fortified the "Interlocking Directorate" and widened the gulf between the teaching and the administrative branches of the profession.

Perhaps by the shift in the policies of the foundation more than any other single motive the college professor was at last driven to the very uncongenial remedy of self-help. The Association of American University Professors was organized to fight his battles and promote his collective interests. By the irony of chance the guides of its destinies in the earlier era were predominantly professors of philosophy, whose habit of chopping logic and splitting hairs gave constant curb to action, and to-day, with our esprit de corps so largely evaporated, it is highly questionable whether enough strength and unity survives in the profession for articulate protest under any provocation. The local chapters of the A. A. U. P. are occupied with endless discussions of minor matters which properly belong to official faculty jurisdiction, while the annual general convention faultlessly formulates wise and useful propositions of which the authorities rarely take any notice at all. Like the Carnegie Foundation, the Association of American University Professors has been of a mixed effect. It has wrought some good, in stemming the tide against deprofessionalizing our vocation. On the other hand, it has shown itself weak in will, lacking in creative power and incapable of giving inspiration. It has, therefore, fallen short of legitimate expectations.

For my *dimitto nunc*, a bright word of cheer might perhaps seem more in order than the occasional touch of flippancy which my presentation of this saddening subject has indulged in. It will be readily supplied by the rampant optimism of the profession. I have to confess myself so unacclimated to the educational topsy-turvy that I have to laugh at it now and then to stop myself from weeping. And I will not even close with an orison for better things, for I should be praying to gods that are no more, than which earth holds no sharper exile. I am too near the end of my career to be swayed in my viewpoints by personal hopes and fears. Moreover, I know that to most of my colleagues the change of which I complain looks like honest-to-goodness progress. The American college has passed through several distinct stages of control. At first it was governed by the church. Later, by the president and the trustees. Faculty control, as the next natural step, was reached by but a few institutions. The present trend is very rapid toward government by the community and the students. In the immediate future, success in the professorial career must hinge on an ability to please the students and the town. There is no collective disposition among the advocates of education to pull against the mock-educational tendency of the times. I have stated things as I see them, and have no remedy to offer. Only this curious question: Shall some tidal wave of culture return the college professor soon or late to his former honorific place in society? Or is the demobilization of the professor a premonitory phase of the disarmament of old moral and intellectual world forces?

WHO IS A MORON?

By Dr. HENRY H. GODDARD

THE OHIO STATE UNIVERSITY

THE answer to this question is of general as well as scientific interest. The term "moron" originally brought into the language for specific scientific use seems to have filled a long-felt want in the public mind, and to-day one meets it in polite conversation, in popular literature of all kinds, from newspapers to novels and poetry, as well as in scientific writings.

The origin of the term is briefly stated. There have been for many years at least three different terms commonly used to apply to persons of defective mentality. These were idiot, imbecile and feebleminded. Each in its turn had originally been applied as a very kindly designation of mentally deficient people. Idiot, which sounds so harsh to-day, was originally taken over from the Greek language "idiotes," meaning having an individuality of his own, or in a sense peculiar, not an obnoxious term to be applied to a serious mental defective. But of course in time it came to take its meaning from that to which it was applied. Likewise, imbecile, which means literally leaning upon a staff or needing support, was also a friendly term. Still more recently, the expression feebleminded has come to be applied to these people with the result that it is coming to be a little unpleasant in its implication.

In 1909, the American Association for the Study of the Feebleminded appointed a committee to devise a classification for the feebleminded. The writer was a member of that committee and made the report which was presented a year later at the annual meeting held at Lincoln, Illinois. The Binet-Simon tests of intelligence with their age grading had just come into use and it seemed feasible to use the terms already referred to for defectives of different age levels. Accordingly, the plan presented was to call those defectives who had no higher intelligence than that of two-year-old children, idiots; while those who had intelligence from three years to seven years, inclusive, were to be called imbeciles. So far, so good. There was, however, a third group with a mentality of from eight to twelve. It was at first thought that we could call them feebleminded. This indeed is the custom in England, but unfortunately for our plan, in the United States the term feebleminded had come to be applied generically to the entire group of mental defectives and every state institution in the country was called an institution for the feebleminded. It was obviously too late to restrict the use of the term feebleminded to the highest group. The only thing that could be done was to keep the term feebleminded in its generic sense as covering the entire group of mental defectives and to select a new term for this highest group. Various words or expressions were tried, such as "deviates" "the almosts" and several others, none of which seemed to have the right sound.

The term "fool" in its good old English signification seemed to be exactly what we wanted. The definition given is "one lacking in common sense, in judgment, or in intelligence." But, good as the term was in old English and fitting exactly the group, it is nevertheless taboo

in modern usage. But no such objection existed for its Greek equivalent "moron." Moreover, fortunately the Greek root "moros" has not been brought into English, except in two words, and it is compounded in each case with another word. The rhetorical term "Oxymoron" is applied to an expression that sounds foolish, but in reality is very witty or sharp "oxus." And, secondly, it appears in the word sophomore, which was a comic word coined years ago by college men to apply to the second-year class, the "sophos," meaning wise, indicating what they thought of themselves, and "moron," meaning foolish, what the upper classmen thought of them. These usages would have no effect upon our proposed use of the term. Consequently, our highest group of the feebleminded was called "moron" in the report of this committee on classification. The report was accepted by the association and the classification adopted.

It will be noted that according to this a moron is a feebleminded person who has a mental age of anywhere from eight to twelve years. But as already indicated the public has found the term so useful that it is being used indiscriminately and without regard to its original definition. As used to-day, it is applied to anybody who is a little bit dull in intelligence, or even, as some one has expressed it, to any one who does not agree with you. Most people to whom the term is applied in this broad sense of rather dull or stupid probably have an intelligence of not more than twelve years. Now if all such people were really feebleminded, there would be no difficulty in the matter. But unfortunately for this problem, such is not the case. There was a time to be sure when we rather thoughtlessly concluded that all people who measured twelve years or less on the Binet-Simon scale were feebleminded. However, we had already begun to discover our error when the war came on.

The war led to the measurement of the intelligence of the drafted army, with the result that such an enormous proportion was found to have an intelligence of twelve years and less that to call them all feebleminded was an absurdity of the highest degree.

Three years ago, William Allen White published an article with the caption, "What is the matter with America?" His answer to his own question was in brief, "The moron majority." According to the army results he was not far from right, if we take the term "moron" to include all the twelve-year intelligences—and add a few of the thirteen years. Of 1,700,000 soldiers tested, forty-five per cent. did not get above the twelve-year limit. Inasmuch as 1,700,000 men were a fair sample of the entire population, we conclude that these figures hold for the people of the country. But if a moron is a *feebleminded* person, it is evident that these people are not morons. To put the question another way: some people with ten-year intelligence or eleven-year or twelve-year *are* morons, but the great mass of that group *are not* morons. Now what are the distinguishing marks? We shall discover before we are through that the answer to that question raises several others of considerable importance, even involving the interpretation of the laws by which we take care of the feebleminded persons in state institutions. If a moron is a feebleminded person, then are not all persons with a ten-year mentality, for example, morons or feebleminded? To answer we must first ask the question, "Who are feebleminded?"

And now must our nakedness be exposed! In this year of grace, nineteen hundred and twenty-six, after three quarters of a century of dealing with the problem and at least a quarter of a

century of intensive study of it, we are still limited to a definition of feeblemindedness that is unscientific and unsatisfactory. We have no absolute criteria of feeblemindedness. In the definition generally accepted by English-speaking people, we appeal to no less than three sciences for our criteria. Our accepted definition reads, "a person of defective mentality (psychology) existing from birth or an early age (biology) whereby he is incapable of competing in the struggle for existence or of managing his own affairs with ordinary prudence (sociology)." Such a definition is not scientific because it is not definite. It is not satisfactory because it is not usable in all cases. It is not definite because in the first place it does not tell us what we mean by a *mental defect.* How low in the scale of intelligence must a person be in order to be a defective? We have already said that at one time we thought twelve years was the limit, but we know that most of the twelve and even the ten and the nine are not defective. Secondly, we say that such defect exists from birth and early age. Existing from birth is definite; existing from an early age is indefinite. However, in both of these cases, it would only be necessary to determine a point by common agreement as the result of study and a determination of the consequences. But the third science appealed to is more hopeless than all the rest. Who can tell exactly what we mean by being incapable of competing in the struggle for existence or of being incapable of managing his own affairs with ordinary prudence? What is ordinary prudence? What do we mean by managing his own affairs? Must he never take advice from any one? Moreover, in this case even if we could decide what we would mean by such expressions it would not remain constant even when so settled. My two-year old nephew is of idiot level and I may call him an idiot without hurting his father's or mother's feelings provided I use the right inflection and have a twinkle in my eye. But he is not feebleminded because he is not defective. He has all the mentality that his age calls for. If when he is three or four he still has only the mentality of two, he will be defective and it will be a mental defect that existed from an early age. So far two thirds of the definition makes him feebleminded. But how about the third? Well, he is incapable of competing in the struggle for existence or of managing his own affairs with ordinary prudence, but that is not because of his mental defect, but because of his age. But again, suppose he is four years old with a mentality of two, still it can not be said that his inability to compete or to manage his affairs is the result of his mental defect. It is just as much the result of his chronological age. And yet such a boy would probably be diagnosed as feebleminded. Certainly, if we adopt the I. Q. system, for his I. Q. would be only 50, well within the limits of feeblemindedness.

Let us now assume that this boy has grown up to fifteen years of age and has a mentality of ten. He is within the moron limit for mentality, and although he is fifteen years of age he is incapable of earning his living and of managing his own affairs with ordinary prudence. He is therefore, according to all the criteria, feebleminded. We will therefore place him in the institution for the feebleminded for care and training. Let us say that he stays there five years. He still has the mentality of a ten-year-old boy, but in those five years he has been very carefully trained. He has learned to take care of himself, to dress and undress himself, to take care of his clothes, to keep himself decently clean. He has learned to work, he can plow and harrow and hoe corn and drive horses, he can

earn twenty or forty or perhaps fifty dollars a month at such work. He has even learned to take care of his money. In short, he is no longer incapable of competing in the struggle for existence or of managing his own affairs with ordinary prudence. Is he feebleminded? Is he a moron? Not according to the definition. He has a mental defect because he has only ten-year mentality; the defect existed from an early age, but the rest of the definition does not apply. Was he feebleminded when he was sent in to the institution at the age of fifteen? Certainly, according to the definition. Then he has been cured of his feeblemindedness! That seems to be an inevitable conclusion. He was feebleminded five years ago, but now he is not feebleminded. But we have always said that feeblemindedness was incurable. "Once feebleminded always feebleminded." We were evidently in error and yet the difficulty is more the result of our definition than anything else. The boy is just as mentally defective as he ever was. Just as feeble in mind as he was five years ago. That condition has not been changed. Yet he was not so defective and so feeble in mind that he could not be trained to become self-supporting and capable of managing his own affairs.

The reader is already asking what that hypothetical case proves. Does such a thing as this ever happen? Yes, that is the reason we are discussing it. We have not resurrected a dead issue for the sake of manifesting our marksmanship. What we have described has not only happened but is happening all the time. It has been happening for years, but we did not know it. Every institution for the feebleminded has some inmates who are sent there as feebleminded but who are no longer incapable of managing their own affairs. This fact has now been demonstrated to us by the work of Superintendent Charles Bernstein, of the institution at Rome, N. Y., who has proved that these people have become capable, by actually putting them out to take care of themselves. He was careful at first to give adequate supervision until his case was proved, but there is no longer any doubt about it. Not only that, but Dr. Walter E. Fernald, late of Waverley, Massachusetts, made a careful investigation of the children who had been taken out of his institution by their friends or relatives. This investigation showed that the great majority of those who were of the moron level were getting along very satisfactorily. A similar study at the Vineland Training School shows the same results. *We are curing some feebleminded in all our well-managed institutions*—if you choose to put it that way. It will perhaps be better to conclude that we have so trained a few of the feebleminded that they are capable of taking care of themselves. Whatever we choose to call it, it is a fact of tremendous significance. But we must be careful that we make no mistake as to what it signifies.

First of all, some of my readers have already raised the question as to the advisability of letting these people go out into the world, even though they can support themselves. Is there not danger that they will marry and bring into the world feebleminded children and so continue this defective race? Yes, there is considerable danger of that, *if it is a danger*. Let us look at it a little more closely. Just what is the danger? First, that we are propagating the feebleminded. Yes, but we have learned how to "cure" them, and when cured (trained) they are very useful. They are happy in doing their kind of work that you and I do not want to do—positions that it is hard to get people to fill. In other words, *we need these people*. They are an essential element in the com-

munity. Why should we be afraid of their having children and bringing up a family like themselves? But suppose they have children that are of a lower intelligence than themselves who can not be trained, will always be a burden upon society? Yes, that would be serious. But there is no indication that that happens in any considerable number of cases. Accidents occur to all classes. Sometimes highly intelligent people have the misfortune of bringing into the world a defective child. There is no evidence that these morons would be any more unfortunate. Perhaps our ideal should be to eventually eliminate all the lower grades of intelligence and have no one who is not above the twelve-year intelligence level. Aside from the impossibility of eliminating half of the population, one may very well question whether such a thing would be desirable, even if it could be done. One thing remains to be considered, the tremendous significance of education for the moron.

The problem of the moron is a problem of education. There would be very few, if any, morons in our institutions for the feebleminded if we had not been mistaken in our theories of education. Henry Fairfield Osborn has said, "The true spirit of American democracy that all men are born with equal rights and duties has been confused with the political sophistry that all men are born with equal character and ability to govern themselves and others and with the educational sophistry that education and environment will offset the handicap of heredity." On the basis of this supposed equality, we have concluded that what is good for one is good for all in the way of education and until quite recently have insisted upon the same course of study for all children. We have now discovered our error, but we are slow to put our new knowledge into practice. The most marked psychological characteristic of the moron is that he is unable to generalize, to handle abstract ideas or to use general principles. He can not handle abstractions or general principles. That being the case, it is as useless to try to teach him subjects that involve generalization and abstract ideas as it would be to train him to run a foot race if he had been born without legs. From this, it is clear to see why we have in the past turned out of our schools so many boys and girls who could not compete in the struggle for existence nor manage their own affairs with ordinary prudence. We have kept them in school and tried to teach them abstractions and general principles, things that they could never learn. The result has been that when they left school they were not only not prepared to do anything by which they could earn a living but they were *discouraged* and *disheartened* and often times *disgruntled* and *anti-social.* It can not be wondered at that many of them became delinquent and finally, criminals. Now that we have learned the facts, the solution is easy. Teach them the things they can learn instead of attempting to teach the things that they can not learn and we will send them out of school trained and even skilled in the doing of things that will enable them to compete in the struggle for existence and in habits that will insure their managing their affairs with ordinary prudence. Moreover, they will have that priceless boon which the moron of the past never did have, namely, the consciousness of *ability in some line,* the *joy of creation* and of independence.

And what kind of training is it that will produce this very desirable result? The reader who wants a complete answer to that question and a demonstration must visit the institutions for the feebleminded where that work has been and is being done. As already stated, Dr. Bernstein, at Rome, New York, has

made some of the largest and most convincing demonstrations, but the same kind of training can be seen at Vineland, New Jersey, at Letchworth Village in New York, at Waverley and Wrentham in Massachusetts—in fact, in most any of the state institutions, although some have gone much farther than others in appreciating the value of industrial training. In brief, the work consists in training these children to work and make with their hands things rather than training them to read and talk about things. These people can all be trained to work efficiently with their hands and when trained they will continue to work efficiently at the thing that they have learned. *They can never be trained to exercise judgment in critical situations.* Therefore, their work must be more or less of a routine nature. But they are not unhappy at this. In fact, they enjoy it if they are not worked too hard and are well treated. This means that it is desirable always for some one to have a certain amount of oversight of such people; in other words, they should always be regarded more or less as children. Provision should be made for their playtime and rest as well as for their work. Our classes for backward children in the public schools have begun to work on these lines, but very few of them have been able so far to carry the plan out to its logical conclusion and to train these children to do the things in school that they are most likely to have an opportunity to do throughout life. This is the problem of the moron.

THE UNNATURAL HISTORY OF THE CLOTHES MOTH

By Professor HAROLD SELLERS COLTON

UNIVERSITY OF PENNSYLVANIA

Introduction

SHAKESPEARE tells us that, "All the wool that Penelope spun in Ulysses' absence did but fill Ithaca full of moths." Can you picture the expression on Ulysses' face when, on his return from Troy, he examined the condition of his civilian clothes? You and I have seen a suit riddled with holes in less than a year. What must have been the condition of Ulysses' clothes after twenty years! I leave you to finish the picture.

When economic pressure turned my attention to the clothes moth with a view to their destruction a happy idea occurred to me. I reasoned thus. If the Mediterranean flour moth which fills our corn meal with its webs is controlled by a little wasp whose larva feeds upon the caterpillar of the moth, may not this same wasp baby feed on the nearly related clothes moth caterpillar? My imagination progressed faster than my experiments, and I saw every clothes closet in the land harboring a little wasp's nest. I was doomed to early disappointment. Although the wasp stung the clothes moth caterpillar and laid its eggs upon the caterpillar's back, and although the baby wasp sucked the clothes moth caterpillar with as much zest as a baby sucks a bottle, yet the experiment failed completely because the bottle was too small. The caterpillar was soon sucked dry and I had the pitiful sight before me of a baby wasp starving to death. With such infant mortality I saw the race of wasps was doomed. Therefore I turned my attention elsewhere in attempting to control the activities of the moth.

Etymology: Origin of the Word Moth

WHEN I talk about moths I am embarrassed because different kinds of insects are called moths. Here we have large flying insects with gorgeous wings like the cecropia moth. There we have the young of the carpet beetle, little hairy creatures about the size of a grain of wheat, which we call the buffalo moth. The fish moth hastily takes to cover under our books and papers. The word moth must have more than one meaning: that of a flying form and that of a crawling form. What do we mean when we say, he "slashed at a moth"? On account of the apparent confusion in the meaning of the word, *moth,* I digress temporarily from *entomology,* the study of the moths, to *etymology,* that study of "roots" which is not usually included in botany.

That great authority, the Oxford dictionary, suggests a double origin for the word moth, one from the same root as midge (mug) and the other from the same word as mouth (motha). I beg to differ with the scholars who compiled the dictionary, because little evidence exists for this idea. I find, up to the middle of the sixteenth century, moth, spelled in ways most unsimplified, as *mohthe* (900), *moththe* (Piers Plowman, 1361), *mought* (Wycliffe, 1381), *mowthte* (1449), *motés* (1520), *mothes* (1551),

referred to anything that consumed and to the clothes moth in particular; as in the Bible, "For the moth shall eat them up like a garment and the worm shall eat them like wool" (Isaiah LI, 8). Floyd writes in his translation of Swammerdam's "Book of Nature," London, 1758: "This little creature, the butterfly, is commonly called a moth but it is noxious on no other account but that it lays those spheroidal eggs out of which the real moths or eating worms are produced in hangings, clothes, etc." In this sense the word appears in the first encyclopedias and in the first dictionaries.

In the time of Shakespeare (1596) people had seen the flying adult arise from the devouring caterpillar. So the name included the flying form as well as the worm. In the "Merchant of Venice": "Thus hath the candle singed the moath." Bacon (1626), a little later, writes in his "Sylva Sylvarum": "The moath breadith upon cloth . . . it delighteth to be about the flame of a candle." Charleton, still later (1668), states, "The moth-fly produced out of the clothes worm."

In encyclopedias the word was early defined to include the flying form. Thus, in Chambers Cyclopedia (1753), under the heading, Phalena, . . . "the name by which authors distinguish those butterflies that fly at night . . . and we vulgurly moths." The sense that the word moth includes a flying insect, for some reason, does not appear in the dictionaries until very late. Webster, the American, in the first edition of his dictionary, 1828, first defined the word to include a whole group of Lepidoptera, while as late as 1885 some English dictionaries do not define moths as flying insects.

We must conclude, therefore, that the word, moth, had not a double origin but that, coming from the same root as mouth, it came to mean something that devours, a maggot. Roland (1656) says, "There are all sorts of Blattae (cockroaches), the soft moth, the mill moth, and the unsavory or stinking moth." Vegetius (1748) has it, "Small maggots or moths which others call lice cause intolerable pain in the intestine." Because one kind of moth was seen to develop into a flying form, a moth-fly, the name, moth, became transferred to a group of flying insects. Yet, to this day, we call the larvae of certain beetles which devour wool, "buffalo moths" and another little insect which devours paper "the fish moth."

Ethnology: Customs of Man and the Clothes Moth

THE necessities of life for civilized man are food, shelter and clothing. This insignificant clothes moth has for thousands of years affected the customs of human beings by attacking one of the necessities of life, wool, the principal material that man uses to conserve the heat of his body. That the moth was a pest to the ancient Hebrews the Bible testifies in many places, but in no place does it give a hint as to how the people reacted toward the moth, except in horror.

Aristotle, at the time of Alexander the Great, in his "History of Animals," Book 5, Chap. 26, however, does give us a hint. "There are other small animals," says he, ". . . some of which occur in wool and woolen goods, as the ses (clothes moth) and these animals come in the greatest numbers when the wool is dusty." We infer by this that the housekeeper in the Greece of Alexander the Great brushed clothes to keep out the moths.

From the writings of that good old Roman country squire, Marcus Porcius Cato,[1] known in history as the elder Cato, we learn that clothes stored in a box in which amarca has been rubbed

[1] "De Agricultura," Chap. XCVIII.

will be safe from moths. I wondered for a while what amarca could be, until in the works of the Roman agriculturist, Varro,[2] I found that it is a substance prepared from the watery dregs of olives after the oil has been extracted. This liquid, after being reduced by boiling to one third its bulk, is recommended as a disinfectant, a sheep dip, a cattle food, and a fertilizer—surely a handy thing to have around the house.

With Pliny (70 A. D.)[3] the methods of conservation became more and more fanciful. "A suit of clothes placed upon a coffin will be forever proof against the teeth of moths." Recipes of this sort were common in the middle ages. A few dead Spanish flies (a kind of beetle) suspended in a house will drive away moths, while clothes "wrapped in the skin of a lion have nothing to fear." We have no way of judging how many housewives followed these methods. In France, about 1737, we know from Réaumur[4] that it was the custom of housewives to beat and brush their hangings and clothes at least once a year and store their clothes in boxes with pine cones (Fig. 1).

That moths influence our modern complex life can not be doubted. Twice a year, spring and fall, for several days at a time, moths direct the steps of the housewife and are the things uppermost in her thought. Indeed, her mind is full of their webs in the daytime and she dreams of them at night.

Too often is a horrible truth discovered—moths in the winter flannels! See! Little Archie's sweater a mass of holes! Gloom sweeps through the household. The housekeeper recalls the labor of certain spring days when all the winter clothes were sunned, beaten, brushed, sprinkled with moth balls, laboriously placed in newspaper bundles and stored away on shelves in the closet or in trunks in the garret. Having followed the best available practice, why is little Archie's sweater in rags? Life is not worth living!

If we are of an analytical turn of mind we will find that, like philosophers, the housekeepers of this day and generation are the followers of several different schools of thought. In one household we might find a follower of the newspaper school, a school which teaches that there

[2] De Rerum Rustica."

[3] "Natural History."

[4] "Histoire des Insectes," Tome III, Memoires 2 and 3, 1737.

Fig. 1.—This picture from Réaumur's Histoire des Insectes shows us that the modern housekeeper has not progressed much further than her ancestors living in 1730, beating the goods once or twice a year being the method used.

is something in printers' ink which is death to moths; in another house will live a disciple of the cedar school, one who puts her trust in a cedar chest and cedar shavings. As we look about we will find a host of schools such as the moth ball, gum camphor, turpentine, keep-the-moth-fly-away-by-any-means, and others too numerous to mention. Sometimes we find a cautious housewife who, to be on the safe side, follows all these schools at once. Although all precautions have apparently been taken, yet occasions arise where damage occurs, notwithstanding all that has been done.

Réaumur and Greasy Wool

A FRIEND of mine once related the sad story of his Navajo blanket. For years the blanket lay on the floor untouched by moths. It became dirty, so he had it scoured. In the summer which followed it was ruined by moths. This experience recalls to my mind the experiments of Réaumur.

Early in the eighteenth century René Antoine Ferchault, Seigneur de Réaumur, performed the first experiments designed to end the voracious career of the clothes moth caterpillar. In passing I may mention that it was Réaumur who first put the manufacture of steel on a scientific basis, who invented porcelain glass and who gave Central Europe a temperature scale. Through his studies of the arts of France and the biology of French animals he added millions of louis d'or to the wealth of his native country. Like Pasteur, his worth was recognized during his lifetime and honors, material and immaterial, were heaped upon him.

Réaumur has written two memoirs on the clothes moth.[5] In the first he records observations on their life history and in the second careful experiments on means for their destruction. Réaumur presents the method of science (the hypothesis, the controlled experiment, the organized record and the conclusion) in such a modern manner that I can not help quoting a small portion of the second memoir.

> I have taken glass bottles to hold my moths so as to be able to observe them and by preference I have taken those cylindrical jars called powder bottles of which the opening is about the size of the bottom. In each bottle I have put a piece of blue or gray cloth . . . with some of the chemicals that I wish to test. Into this I throw a score of hungry moths and cover the top with paper. These experiments are of such a nature that without great ingenuity they can be indefinitely varied and are not too difficult to repeat if we wish to leave no point uncovered.
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> Although the moths are common enough yet I have needed so many thousands of them in my experiments that at times I have been embarrassed to know where to procure them. Those whom I set to hunt them have searched thoroly all the eaten furnishings before they could collect a hundred. On the other hand moths that I raised in my bottles, which have changed to butterflies, which have laid eggs, have given me a most abundant crop. Still I have failed to get enough. I have searched in the proper season for the butterflies that the moths produce, and have shut them up with pieces of material on which they have laid their eggs. Although they are perhaps less fertile than when at liberty yet they multiply about twenty fold. . . . (In this way I procure) all that I wish. . . .
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> . . . . We never see moths attached to the fleece which covers the back of sheep. . . . Fleece removed from the back of sheep which has received no treatment are hardly more damaged than that which is still on the backs of the animals. . . . In the case of wool the very first thing that we do is to make it suitable for moths to eat. These wools that have received no treatment are called greasy wools. They are sensibly greasy to the touch of our fingers. The first process is to remove the grease and then the moths do not spare the wool.
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> . . . . This suggests to us to add to the woolens that we use some of the original grease that has been removed and see if we can make them distasteful to the moths, although we add so little that it is not apparent. It is necessary therefore to prove either that the grease is deadly to the moths or not merely to their taste. I have shut up some very vigorous moths alone

5 "Histoire des Insectes" (1737).

with greasy wool and others with pieces of cloth that I have rubbed upon the wool. I have seen the one and the other on short commons for several weeks following while a third series that had other wool at their disposal gorged themselves. The former came to eat and at length turned into butterflies. Times of famine force them to eat food that in less happy times is repulsive to them we conclude that moths will live on wool even if it is little seasoned to their taste.

I have inclosed others with pieces of wool of two colors one of which was rubbed against greasy wool and the other had not been so treated, the one was blue and the other was gray. In other bottles I made the opposite arrangement that is I put the gray pieces that had been made greasy and the blue pieces that were not. The moths constantly ate the one and never touched the other. It was rare that they ever detached a hair.

By the same methods as we preserve little pieces of cloth so we can preserve great hangings. . . . Nothing is easier than to rub the hangings with greasy fleece to protect them from moths. The materials are not altered the least in the world. By the eyes you cannot tell the rubbed part from the part not treated.

In the place of rubbing the furnishings and other materials with fleece we can get the equivalent effect by several methods. The grease you can get at an apothecary's where it is called lanaline. If you wish to get it cheaper it may be procured from the hot water in which (crude) wool has been washed. Without going to the trouble of trying to separate the grease from the water, all that is necessary is to dip a brush in the water and lightly pass it over the goods to be preserved.

Besides lanaline (the grease from wool), in a similar way, Réaumur experimented with about everything found in the pharmacopeia of his time. Turpentine, of all that he tried, proved the most effective in killing the larva. One drop, he states, will kill all moths in twelve cubic inches of air.

Before discussing the results of Réaumur with lanaline and turpentine we must consider the animals with which he worked. Although two species of carpet beetle larva and three species of moths will eat wool, we will pass by the carpet beetles and consider but two of the clothes moths species. The two clothes moths of importance can be distinguished best by the houses which the caterpillars build. The web-weaving moth, *Tineola biseliella,* builds a permanent house, while the case-carrying moth, *Tinea pellionella,* is a nomad and carries his house about with him. The former is our common moth, while the latter was the moth described in Réaumur's memoir and which is apparently the clothes moth of literature.

Although the case-carrying moth is described as common in this country recent investigators,[6] including the author, have failed to find a single one.

With the web-weaving moth the author repeated Réaumur's experiments with greasy wool, washed wool and washed wool treated with lanaline with no conclusive results—the moth seemed to thrive on all three grades of wool about equally well.

He repeated also Réaumur's experiments with turpentine, but found that it only killed in relatively tight containers and then failed to kill every caterpillar. Therefore it appears that the case-carrying moth, *Tinea pellionella,* behaves differently from the web-weaving moth, *Tineola biseliella,* and things that will harm one will not harm the other. In the future it must be understood that all references in this work have to do with the web-weaving moth.

Repellents

IF defensive tactics will drive away the clothes moth, why start an offensive? Can we raise effective defenses about our goods? Greasy wool, turpentine, gum camphor and naphthaline have each been reported in this class. If repellents are of relative value—that is, if only a few of the enemy survive on our goods the defenses are worse than useless. We demand absolute protection, even if we

[6] Benedict, *Science,* Nov. 9, 1917, p. 462; *Science,* Apr. 19, 1918.

must drive our trenches far into the enemy's country. It behooves us, therefore, to inquire whether absolute protection is afforded by repellents.

Benedict[7] performed experiments directed to find dyes for woolen goods which would either repel or poison moths, and would not hurt baby, as he expressed it, when he sucked mother's dress. His experiments, which were cut off by the war, led to no conclusions.

Greasy wool proved no repellent in the experiments of the author on our web-weaving moth. Indeed the grease seemed to add a necessary condiment as the caterpillars flourished upon it. When it was gone you could hear them gnash their teeth for more! Turpentine, gum camphor and naphthaline in open cages had some repellent effect, but some bold moths held their noses, slid surreptitiously in and laid a few eggs on the exposed material which had been dusted or sprinkled with the supposed repellent. If not inclosed in airtight containers with turpentine, camphor or naphthaline the larva will not perish. Nevertheless, liberal applications of naphthaline crystals will give some protection and in certain cases may be quite effective.

Although a number of other substances have been found to slightly repel the moth, but since they fail to give absolute protection, none are to be recommended at the present time.

Ethology: The Habits of the Moth

BEFORE we can plan a campaign to exterminate any animal we must know the principal events of its life history, its habits and its instincts. By such knowledge alone can we find at what stage it is most vulnerable and what instincts or habits may be made to aid in its destruction.

The web-weaving clothes moth, *Tineola biselliella*, from the tip of the long thin abdomen of the female moth-fly deposits the little white eggs under the loose hairs that cover the woven yarn. These eggs, three of which, if set end to end, will scarcely reach across the head of a pin, must not be confounded with the feces of the caterpillar, which are frequently called "eggs" by the housewife. If not disturbed at the end of seven days the eggs will hatch; out of each will appear the little white caterpillars with yellow heads which are the bane of the housewife (Fig. 2). At first this worm is so small that it will scarcely reach across the head of a pin. Very slow is the growth. In the summer three months and in winter nine months intervene before the juicy caterpillar is half an inch long and is ready to transform into the winged form, the moth-fly. Although the caterpillars feed on wool throughout this period of their lives, when they are small, it is on loose hairs that they browse; it is only when they are large that they eat holes in the goods. As these little moths are semi-transparent, the color of the cropped wool in their intestines renders them so nearly the tone of the goods on which they are feeding that they are easily overlooked. The observant housekeeper, however, is sure to spot them by the little silken tunnels that they build. For this purpose not only do they use the silk produced by themselves but also they use bits of wool and even their own feces. As Réaumur exclaimed, "They are Hottentots indeed who build their houses out of dung!" It is in such a house or cocoon that the moth transforms and from which it emerges as the little yellow moth-fly. From a devourer and consumer, the moth becomes a creature in itself unbelievably harmless; unable to feed, for its mouth is incompletely formed, it flutters around for a brief ten days, finding its mate or laying its eggs. Its duty to its race complete, it flutters to the floor and dies.

[7] *Science*, April 19, 1918.

FIG. 2.—THE TRANSLUCENT EGGS OF THE CLOTHES MOTH ARE QUITE SMALL (THREE END TO END WILL EXTEND ACROSS THE HEAD OF A PIN). WHEN LAID UPON WOOL, THE NEWLY HATCHED CATERPILLARS START TO FEED AT ONCE.

The food of the clothes moth caterpillar is hair. Hair, like the flesh of an animal, is composed of protein, but to be a food must be dissolved. This the clothes moth can do. In its stomach, cells produce a ferment that can render this hair protein soluble so that it can be absorbed and assimilated. All the nourishment of the caterpillar comes usually from this one source, but under certain conditions it can live on finger-nail clippings and feathers as well. It is well to remember that the cracks in our floors contain plenty of food for moths.

The clothes moth manufactures drinking water.[3] The hair contains among the various elements which compose it the element hydrogen. This combines with the oxygen of the respired air to form water. Although the caterpillar never drinks a drop of water in its life, yet, as everybody knows, it is a very juicy animal.

On the conservation of water the life of the moth depends. Since it must manufacture all it demands, so it must see that none is wasted. The two ways by which animals lose water are by evaporation from the surface of the body and by the excretion of urine. Evaporation limits the habitat of the moth to more or less humid regions. The moth, by a peculiar method of excretion, conserves the water in the urine.

Experiments have been performed which indicate that the web-weaving clothes moth does not thrive in all climates because it can not conserve its

[3] Babcock, S. M., 1912.

water supply. Therefore, in a hot dry climate, such as southern Arizona, in summer; or in the sun on a sunny day in the east, water is removed faster than it is manufactured and death ensues from drying up. On the other hand, a hot moist climate is bad because mould grows in the wool. A cold dry climate is harmful because it slows up the life processes of the animal. Freezing does not kill, but quick thawing does.[9] A warm dry climate, such as we have in our homes in winter, does not kill but slows up the development of the animals. Clothes moths do best in a warm moist climate, such as the eastern states enjoy in summer, for here it is not moist or hot enough to grow mould in the wool, but in the dark it is moist enough to prevent excessive evaporation.

In most animals the elimination of the nitrogen of the body waste is in the form of urea, which is dissolved in water and passed out of the animal. The clothes moth, in common with birds and certain desert animals, excretes these wastes as uric acid in little crystals which pass out almost dry. In food and drink, therefore, the clothes moth is peculiar.

Economic Entomology: The Means to control the Pest

In planning to keep moths out of goods it is well to know that a large voracious caterpillar feeling the pangs of hunger will eat a hole through newspaper (Fig. 3), but finely woven glazed cotton goods will turn their fangs. However, a newspaper bag will stop the little ones, so if bags of glazed muslin are not available paper is better than nothing in which to store our goods.

Two of the most important instincts of the moth and the moth-fly are their attraction to dark places and their desire to feel the pressure of two surfaces against their bodies. Thus they crawl between cracks leading into boxes or folds in the goods. Few cracks between the lids of boxes or trunks are too small to keep them out. Therefore, bags of some kind are necessary—cheese cloth is worthless, and paper not sure; bags of glazed muslin answer the purpose.

Goods that are handled as often as once a month or clothes that are worn at frequent intervals have nothing to fear from moths. Since the eggs are extremely delicate, a touch with a fine camel's hair brush will break their shells. The caterpillars indeed have an instinct which often leads to their destruction. Their reaction when frightened is to "play 'possum." They become rigid, bent into a half moon. If not in a silken tunnel, disturbing the goods easily displaces them. Shaking, followed by brushing, will rid the goods of most of the eggs and caterpillars. It fails when newly hatched caterpillars are present, caterpillars that are so small as to be invisible to the naked eye, a few of which not displaced by brushing will be sure to be overlooked. To kill all they must be "gassed."

The method of work in studying lethal gases is very simple. Into two

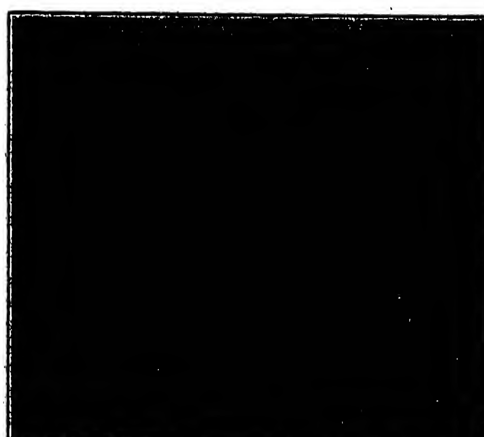


Fig. 3.—Contrary to the usual experience of housewives, the clothes moth caterpillar, if starving, will gnaw a hole through a piece of newspaper to get at food.

[9] Howard and Blaisdell, Bull. 22, N. S., Bur. Ent., U. S. Dept. Agr., 1900.

wide-mouthed bottles an equal number of caterpillars are placed on two similar pieces of an old blanket. The top of each bottle is now covered with a piece of porous paper, such as Scott tissue toweling, and snapped to the neck of the bottle with a rubber band. One of these bottles is placed in a trunk in which some poisonous gas is to be tested and the other bottle, called the control, is kept under similar conditions but not exposed to the gas. If, at the end of two days, a week or ten days, we find that the caterpillars in the trunk are dead and the controls are alive, then we can draw the conclusion that it was the gas that killed them. To be sure that this conclusion is correct, the result is verified by repeated trials.

By these means a large number of substances have been tested. Some have been common substances, such as tar camphor, and others less familiar, as para-di-chlor-benzene. Each substance was tested first in a corked bottle with the caterpillars and then in a bottle covered with a single layer of Scott tissue toweling. If the worms were killed under these conditions, they were then introduced to the same substances in a trunk. It was soon found that no substance, not even that evil-smelling carbon bisulphide, as recommended by entomologists, was strong enough to kill the caterpillars in an ordinary trunk. As the gases used were in every case heavier than air, they tended to pass through the porous sides and bottom and did not fill the trunk with vapor. The next step was to render the trunk reasonably gas-tight. A heavy gas is like water: if we have the trunk airtight we can fill it up to the level of the lid crack before the gas will overflow out into the room. The best means to render the trunk gas-tight was found to paraffine the inside of it. This is easily done. A quarter of a pound of paraffine is melted in a pan on the stove, then carried out of doors, an important precaution, and poured into a quart of gasoline. The resulting yellow liquid is applied to the inside of the trunk with a brush, the precaution having been previously taken to paste muslin over any large holes. A trunk so paraffined should hold water. If it will hold water it will also hold gas. Under such conditions and under these alone will carbon bisulphide, tar camphor or para-di-chlor-benzene kill moths. Although a few moth balls placed in the pocket of Cyril's coat or moth balls placed in a cardboard box may repel the winged moth-fly, yet, if one caterpillar is overlooked in the brushing, considerable damage must result.

The red cedar chest is an old friend among our defenses against the moth. Experiments performed by the Department of Agriculture[10] have shown that our trust is not placed in vain. It has been demonstrated that the value accrues from two facts, first, because the chests are tight containers similar to the paraffine trunk and, secondly, that some sort of fumes are given off by the cedar wood which will kill young caterpillars and eggs, although not injuring the older ones.

It is needless to say that for killing moths the various substances examined were of very different value. Indeed, while some were found to be of worth, most were valueless. Some gases that will kill moths will also injure man, so that these were discarded in the beginning. Some others will destroy the color of the dyes. Some are inflammable; some difficult to procure; and some too expensive. Without further discussion I may state that naphthaline or ordinary tar camphor in the long run is the best. As used in the household the fumes are harmless to man; it will not destroy the color of the goods; the fumes are non-

[10] Black, E. A., U. S. Dept. Agr. Farmers Bull. No. 1051, 1922; U. S. Dept. Agr. Farmers Bull. No. 1346, 1923; U. S. Dept. Agr. Farmers Bull. No. 1353, 1923.

inflammable; it can be procured at any drug store; a little goes a long way; and it is quite inexpensive. It is ordinarily carried in stock in two forms, either as crystals or fused, when it is known under the name of moth balls. In a paraffined steamer trunk one half a cent's worth of crystals is equal in killing power to about twelve and a half cents' worth of moth balls at the present price of naphthaline (25 cents a pound), but the crystals evaporate four times as fast. When used in an ordinary trunk the amount should be doubled. Although one ounce of crystals or a pound of moth balls in a paraffined trunk will quickly kill the eggs and the newly hatched caterpillars, to kill the large ones ten days is necessary. It is on this information that the recommended practice is based.

This practice is planned to adhere as closely as possible to that already in use by most housekeepers. It varies from this only where the ordinary methods are worthless. The reason for each step should be in mind. Indeed, if this is so, goods need not be ravaged by moths.

(1) The goods are placed in bags of any closely woven cotton material or in bags of stout paper, the open ends of which should be so secured that there will be no crack or crevice by which a worm or mothfly could gain access. I know of two good reasons why this should be done out of doors on a sunny day. First, direct sunlight with a temperature of 112° F. will kill the larva in a few hours; and, second, since mothflies hide in dark places none will be about when the goods are placed in the bags.

(2) The bags are now placed in a paraffined trunk, upon the bottom of which is sprinkled a few ounces of crystallized tar camphor. Why? In the first place, the trunk is paraffined to prevent the escape and hence the dilution of the gas. In the second place, crystallized naphthaline is recommended because it is about four times as powerful as moth balls.

(3) In this trunk the bags should remain over ten days. Should there be a fat caterpillar hiding in the pocket of father's overcoat, ten days in an atmosphere of naphthaline will end his career.

(4) After the ten days are up the bag may be removed to a shelf in a closet or to any other convenient storage place. This will leave the trunk available for more bags of woolen goods. The last load may remain in the trunk all summer. In using the trunk or chest I must insist that three precautions be taken. As a killing agent outside of a tight container, tar camphor is not sure; as a repellent it is of doubtful value, so trust the bag to keep out the moths. Do not open a bag after it has been in the naphthaline trunk or in the chest. A microscopic caterpillar may be hovering around the opening only too anxious for a chance to rush in. If the bags are properly labeled as to contents, they will not need to be opened very often. Occasion sometimes demands that we gain access to a sterile bag. After the bag is opened and closed and after the opening has been secured the bag should again be placed in the trunk or chest. If these cautions are heeded and precautions are taken, Penelope need not worry over moths.

While every housewife has sufficient resources to paraffine a trunk, yet a few may wish to prepare a more permanent receptacle. Indeed the paraffined trunk may prove too small, as the author's wife discovered. Recalling Professor Howard's[11] description of a chest in the household of a "Washington gentleman," a large chest lined with tin, the author constructed two on similar lines, each as large as two or three ordinary trunks. Substituting galvanized iron for tin and constructing a moth-proof lid crack, his delighted wife can now

[11] U. S. Dept. Agr., Div. Ent., Bull. 4, N. S.

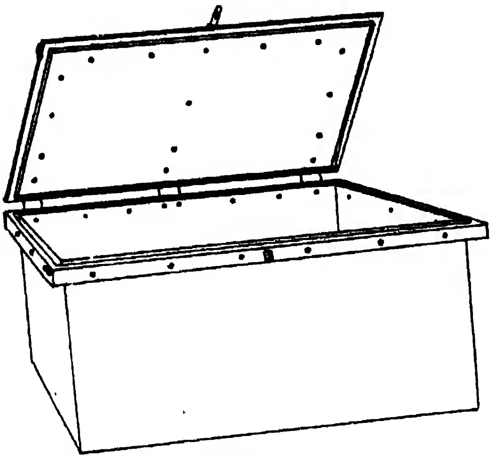


FIG. 4.—A CHEST DESIGNED AND BUILT BY THE AUTHOR FOR THE STORAGE OF WOOL FABRICS. IT CONSISTS OF A BOX 5 FT. LONG, 2½ FT. HIGH AND 2½ FT. WIDE OF GALVANIZED IRON. AROUND THE TOP OF THIS BOX IS BOLTED A 2-IN. X 2-IN. FRAME IN WHICH THERE IS A GROOVE. THE LID ALSO OF GALVANIZED IRON SUPPORTED BY A WOODEN FRAME HAS A FLANGE WHICH FITS INTO THE GROOVE IN THE TOP OF THE BOX; THE GROOVE BEING FILLED WITH COTTON WOOL OR COTTON FELT MAKES A MOTH-PROOF CRACK. (SCALE 1/18 NATURAL SIZE).

store away her furs, the children's "winter flannels" as well as small rugs up to five feet wide, with perfect ease of mind. Charged with two pounds of naphthaline flakes her goods are doubly safe against the ravages of moths. (For details of construction of the chest, see Fig. 4 and Fig. 5.)

Architects, who are ingenious, can even design a moth-proof closet. If a

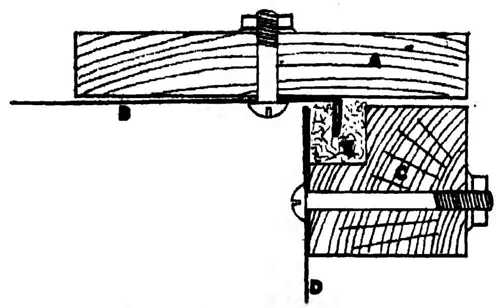
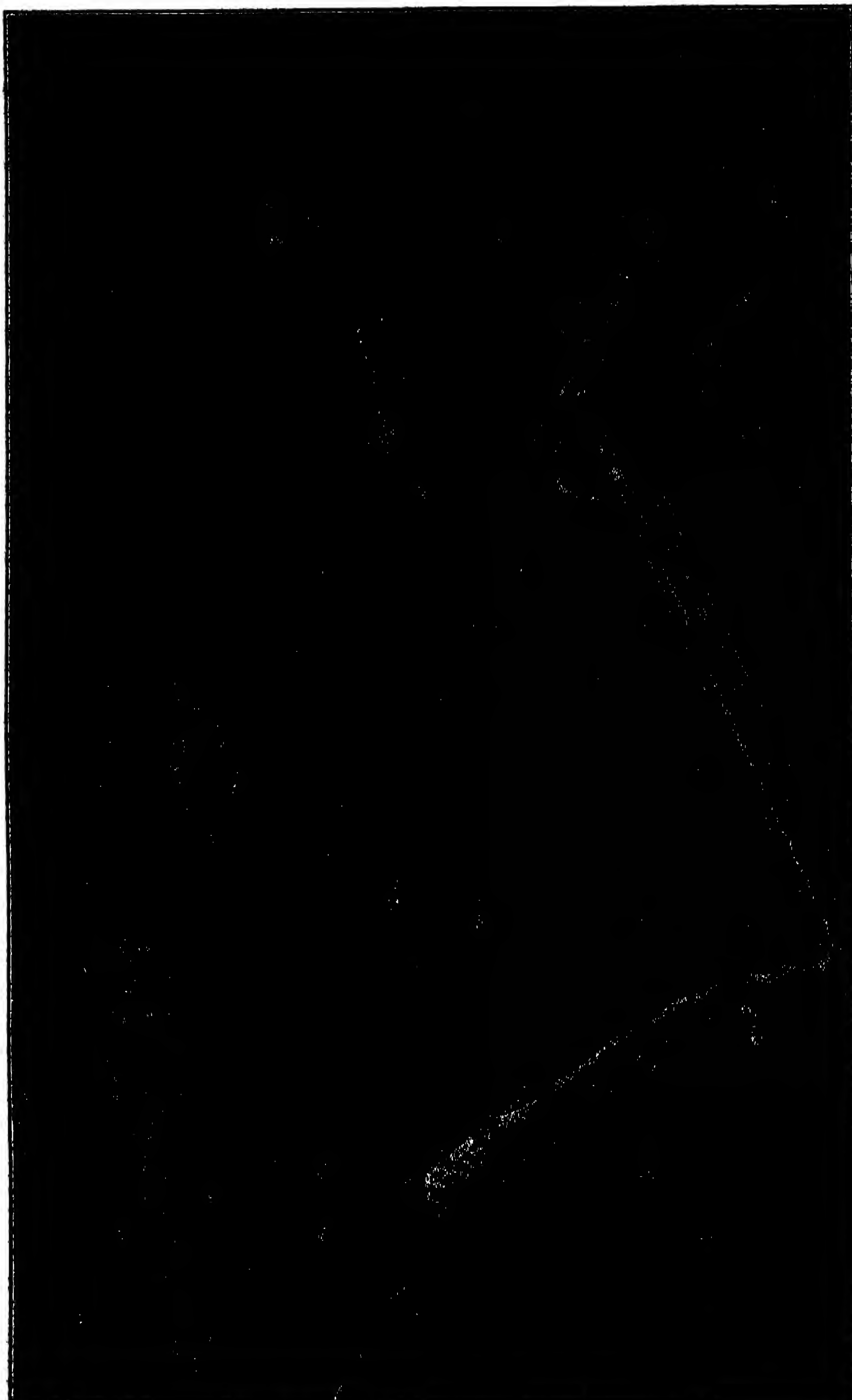


FIG. 5.—DETAIL SECTION OF THE JUNCTION OF LID AND THE TOP OF THE BOX. THIS SHOWS HOW A MOOTH-PROOF CRACK MAY BE MADE. TO THE WOODEN LID FRAME (A) IS BOLTED A GALVANIZED IRON LID (B) WHICH HAS A ⅝-IN. FLANGE ON THE OUTER EDGE. THIS FITS INTO A GROOVE (E) WHICH IS MADE BY THE SIDE OF THE BOX (D) AND A RABITED GROOVE IN THE BOX FRAME (C). THE GROOVE (E) IS FILLED WITH COTTON FELT OR COTTON WADDING WHICH WILL PREVENT THE PASSAGE OF MOTHS. (SCALE ½ NATURAL SIZE.)

small tight door with a rubber gasket is provided and a charge of naphthaline added, one could hang up the winter clothes, even the fur coat, without further treatment with the absolute assurance that no damage will occur over the summer.

We must remember that naphthaline gas kills, that naphthaline gas is heavier than air, that moths seek dark places to lay their eggs, that moth-proof cracks and naphthaline tight containers can be constructed; with all this knowledge before us, the unnatural history of the moth will come to a conclusion.



THE MEDICAL CENTER AS IT WILL APPEAR WHEN COMPLETED.

THE MEDICAL CENTER IN NEW YORK CITY

By C. CHARLES BURLINGAME, M.D.

JOINT ADMINISTRATIVE BOARD OF THE MEDICAL CENTER

Disease is as ancient as man himself. Hardly was he born before he began the fight against this, his natural foe. But for thousands of years he clung to the belief that he had been entered by an evil spirit or was being visited by the wrath of an offended deity, and so tried to combat it with charms, incantations, dances and sacrifices to the gods.

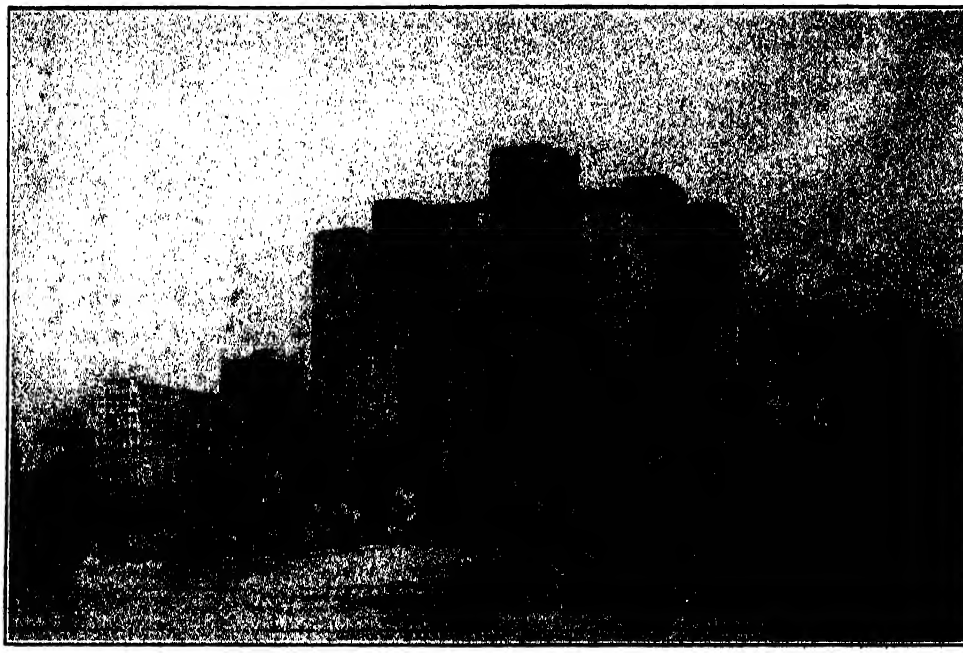
It is difficult for the present generation to understand that for these ages past medicine and disease have been surrounded with mysticism and confounded with religion; and yet men born in the nineteenth century believed in these things. Our great-grandparents found it easier to give credence to these ancient doctrines than to the theory that disease was caused by a germ. It was in the early days of our own New England states that there was belief in some of these old conceptions, as witness the Salem witchcraft, when learned men of medicine testified that children with epileptic attacks had been bewitched, and often the "guilty witch" was destroyed by the state.

We can with interest, and even amusement, look back upon the doctors' prescriptions of but a short time ago which contained dozens of ingredients, often of superstitious origin, such as moss from a dead man's skull. As late as 1820 the old Bedlam Hospital in London exploited its insane patients as a source of income, exhibiting them "in cages like monkeys at a penny a look."

Medical science has traveled far since the superstitions of these early days, but most of the journey has been within two generations. Curiously enough, the beginning of this enlightenment did not come about through any understanding of what disease really was, nor as a result of logical thinking in regard to its treatment, but as a by-product of the growing sciences of chemistry, biology, physics and other branches of learning. It was in the reflected light of these growing sciences that scientific medicine had its origin.

Since the introduction into the medical world of bacteriology by Pasteur and Koch, but a generation ago, scientific knowledge in medicine has increased so tremendously as to have broken medicine up into multiple specialties which are ever increasing. So rapidly did this specialization develop that the beginning of the twentieth century found the medical sciences in isolated groups which had sprung up around the work of some particular man or line of research. The resultant lack of coordination has sharply limited progress, and the tendency toward centralization is now as intense as was the preceding trend toward individualized specialization. The medical center movements all over the world are an effort to physically, and thereby intellectually, bring together the scattered elements of medical research, medical teaching and medical care.

These groupings of isolated schools of medicine, dentistry, nursing, pharmacy, public health and social service, with general and specialty hospitals and institutions for research in the different branches, are gradually taking place in varying degrees of completeness, as, for example, at Johns Hopkins University, the Mayo Clinic, Harvard University, St. Louis and in Chicago; but New York, despite the unusual resources at her very



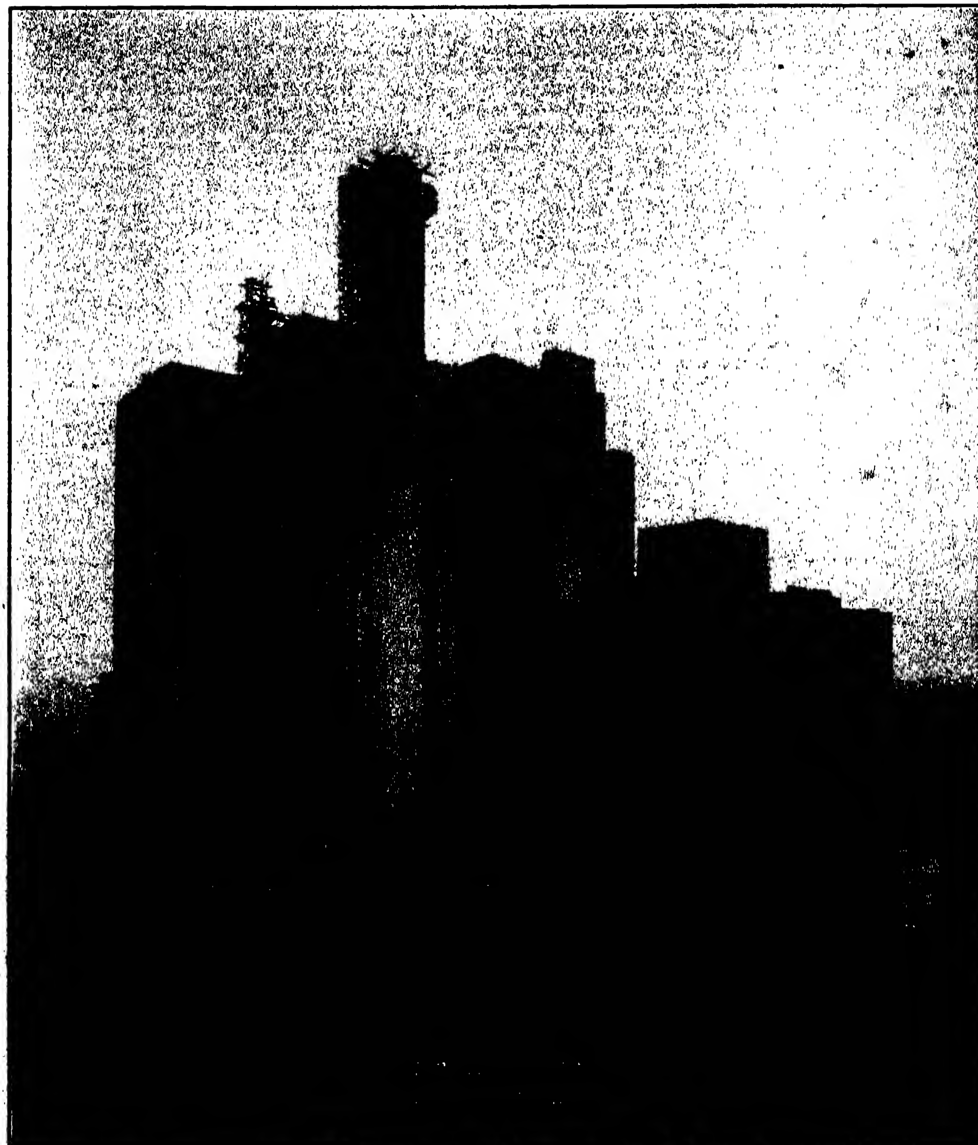
THE PRESBYTERIAN HOSPITAL
WITH HARKNESS PAVILION AND BABIES HOSPITAL FROM THE ARCHITECT'S DRAWING.

door, has been somewhat tardy in taking her place.

The New York Medical Center had its beginning in 1911, when an agreement was executed between Columbia University and the Presbyterian Hospital, whereby the latter became a "teaching hospital" for the university's school of medicine, the College of Physicians and Surgeons. This eventuated in 1921 in the formation of a Joint Administrative Board to develop a complete medical center. These two institutions formed the nucleus of what in the past five years has become a most unusual grouping of long-established specialty hospitals and research institutions. Already, six institutions, each outstanding in its own particular field, have, by executed agreement, taken their places beside these parent institutions.

In 1924 the New York State Psychiatric Institute and Hospital became associated and the following year the Babies Hospital of the City of New York, the Neurological Institute of New York, Vanderbilt Clinic, the Sloane Hospital for Women and the Squier Urological Clinic all became part of the movement. To the Joint Administrative Board were sent additional representatives until to-day it is constituted as follows: Wm. Barclay Parsons, John G. Milburn, Walter B. James, M.D., Dean Sage, Edward S. Harkness, Henry W. de Forest, John Sherman Hoyt, Robert Thorne, Newcomb Carlton, Jackson E. Reynolds and W. E. S. Griswold, with William Darrach, M.D., dean of the medical school, as an advisory member, and C. C. Burlingame, M.D., the executive officer.

These institutions have all pledged themselves to remove the conditions which for generations have handicapped the care of patients, teaching and research by rebuilding together on a single

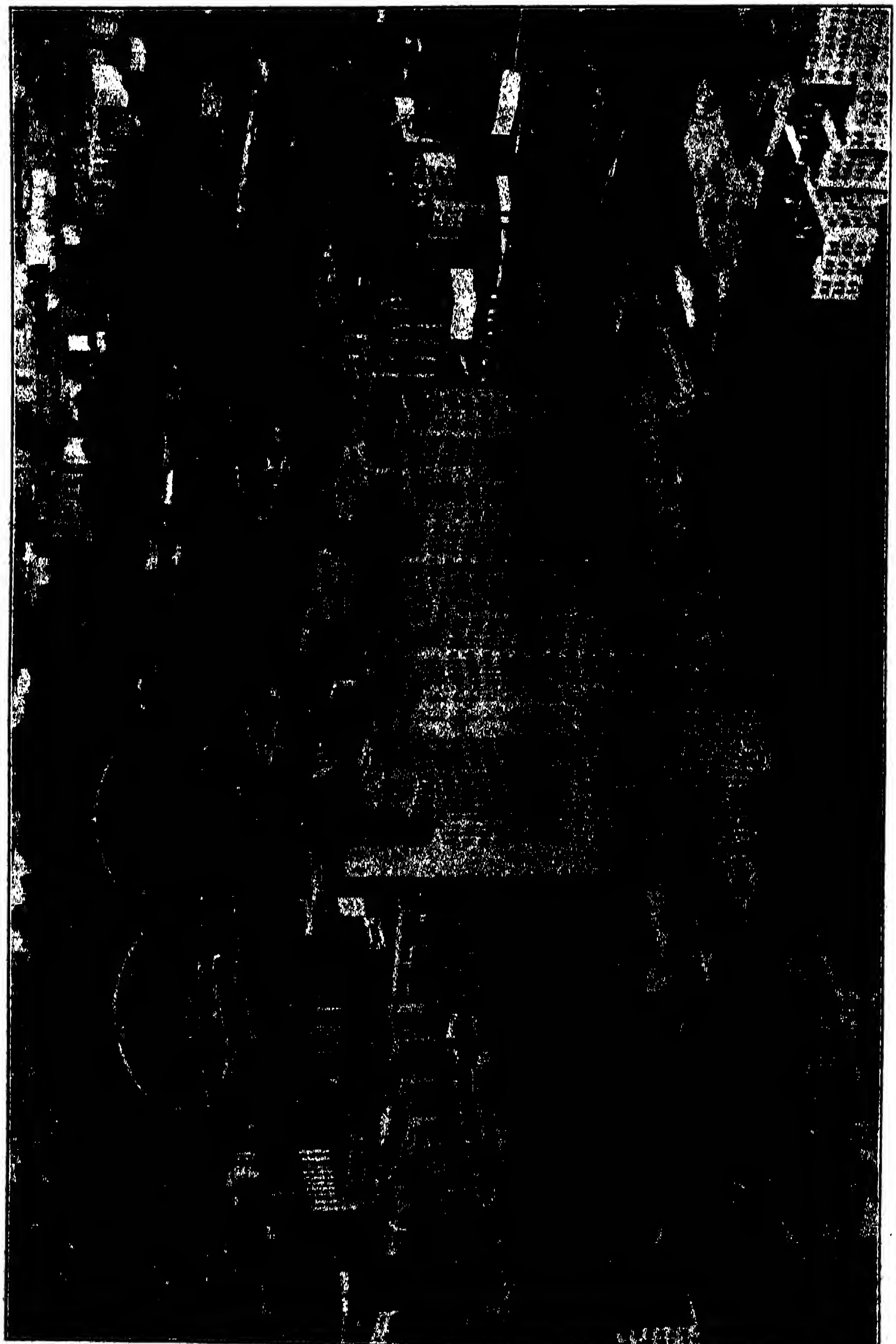


THE PRESBYTERIAN HOSPITAL
AS IT APPEARED ON AUGUST 27

plot of ground of twenty acres at Broadway and 168th Street.

Already hospital and school buildings, involving over $19,000,000, are under way with the prospect that in 1928 most of the institutions will begin to operate together as units of New York's Medical Center.

Each institution is being reconstructed with a realization of the responsibility that it must carry as its own specific part in medical progress, but it is inspiring to note that it is also rebuilding with a full realization of the part it must play as one of the group engaged in the high purpose of blending insti-



AEROPLANE VIEW OF CONSTRUCTION TO OCTOBER, 1926.

tutional ambitions with "whatever is best for scientific medicine and for those who are sick."

The practical accomplishments to date are significant. A twenty-two-story combined building, costing nearly $15,000,000 to build and equip, is more than 50 per cent. constructed. Under this roof, all obstacles of distance eliminated, will be the Presbyterian Hospital in the City of New York, the College of Physicians and Surgeons of Columbia University, the Sloane Hospital for Women, the Squier Urological Clinic, the Vanderbilt Clinic and the Harkness Private Patient Pavilion. The resources of these institutions have been conserved by doing away with duplication of effort and unproductive competition between them.

During the month of December the steel work was completed for a fourteen-story building, costing $1,100,000, to house the Presbyterian Hospital School of Nursing. This school is establishing a new policy which limits their students to three hundred as the ideal number that can be taught in a single teaching unit. This policy is another departure from the old order of things when the number of pupil nurses was determined solely by the hospital nursing needs rather than by the ideal conditions for instruction.

Excavations are nearly completed for the New York State Psychiatric Institute and Hospital, which will cost in excess of $1,600,000. This is to be a twenty-story building, with the first ten stories a hospital for a special group of two hundred patients and the upper half of the building devoted to facilities for instruction and for research in the problems of mental diseases. It will become the ultra-scientific center for the New York State hospital system with its 45,000 beds.

The Neurological Institute of New York has completed plans for a million dollar building which will care for two hundred patients, while the management of The Babies' Hospital is completing plans for a 160-bed institution. The actual construction of both of these buildings is scheduled to begin during the winter.

Stupendous as this grouping already is, there are still other branches which must be included before the picture can be called complete. To this end active negotiations are under way for the inclusion of dentistry, which has become so interwoven with the study of medicine that it can not be ignored, for all allied schools and other types of specialty hospitals, even to provision for the care of the convalescent patient.

The entire movement has been referred to in a materialistic way as the greatest building operation of its kind in the world; the expenditure, at one time, for hospital and educational buildings has been pointed to as without precedent; as the highest hospital building in the world, it has attracted attention; as a unique plan of coordination it has become interesting; but it is the opportunity for complete intellectual unifying of scientific medicine in all its branches which has been the impelling motive in the movement.

THE DISCOVERY OF ANESTHESIA

By Dr. C. A. H. SMITH

THE commonplace use of various agents for the relief of pain in surgical operations is taken for granted at the present time, and the most important discovery of American medicine in the last century is in danger of being forgotten. Surgery without anesthetics is too horrible to contemplate, yet not until 1846 was there a practical means of controlling pain. But at the time there were four principal claimants of the title of discovery, all of them Americans and all responsible for so much bickering and blustering that the true magnitude of the discovery was clouded and is to-day forgotten, while all the mechanical products of American ingenuity are still praised as the greatest contribution to humanity.

The slightest operation in pre-anesthetic times was deservedly viewed with horror and repugnance. John Hunter, the famous English surgeon, spoke of operations as "humiliating examples of the inexpertness of science," and of surgeons as "no better than armed savages."

The surgeons themselves looked upon operative surgery as the lowest and poorest branch of the profession, and care and finesse was forgotten in the attempt to minimize the patient's suffering.

Still there were some who became hardened to the profession, and in 1784 one James Moore, a member of the Surgeons Company of London, published a pamphlet descriptive of a "Method of Preventing or Diminishing Pain in Several Operations of Surgery." There was no remarkable advance described in his paper, but the introductory paragraphs are so accurate a comment on early medicine that they are well worth repeating.

He says:

> If any of the professions were in a particular manner to be distinguished by the name of humane, we might naturally expect—it would be that whose particular object it is to relieve the sufferings of humanity. And, if a greater degree of compassion and sympathy were looked for among any one class than any other, we should expect to find it in the breasts of those who pass their lives in the duties of so benevolent a profession as physicians. Physicians have been accused of a want of feeling for the distresses of human nature and surgeons of actual cruelty.

The lack of consideration for those in pain was not, however, due to lack of interest but to a lack of agents to control pain. From the earliest period of medical history there are stories of various schemes to control pain. Opium, laudanum, alcohol and such drugs were tried and found wanting. After Mesmer spread his mysterious doctrines, hypnotism was used with considerable success. But there was nothing that was easily and universally applicable to all cases, and the general public had good reason for avoiding the early hospitals.

It remained for a young American citizen to perfect a process that is still in use with very little change. The natural expectation would be that he would be rewarded for his work, but, to the contrary, never was a man more abused and never were more absurd attempts made to discredit a product of patient and careful experimentation. Even to-day there are some groups that wish to deny any honor to him, although for the great part this is due to local sectional jealousy and not from the violent per-

sonal hatred that was so evident at the time.

There were several individuals, all of whom were possessed of sufficient experimental information to obtain credit for the discovery, but either through fear, carelessness or lack of proper appreciation of its value they all withheld their knowledge till after Dr. W. T. G. Morton had braved the unknown and demonstrated the possibilities of ether. A careful study of the evidence can not help but convince the unprejudiced observer that Morton was alone responsible for the introduction of ether into use as an anesthetic, although Dr. Horace Wells, of Hartford, Connecticut, and Dr. Charles Jackson, of Boston, were working along the same lines and Morton very probably worked with them to some extent. Dr. Crawford Long, of Atlanta, Georgia, had used ether prior to Morton, but as I shall show later did not fully appreciate the importance of the material.

Morton was born in Charlton, Worcester County, Massachusetts, on August 19, 1819. His education was slightly better than the ordinary and from earliest childhood he tried to fit himself to become a physician. From various reasons, principally lack of funds, he was unable to achieve his ambition and we find him in early manhood shifting back and forth from one job to another. A disastrous business venture caused him to become dissatisfied with a commercial career, and he decided to take up some profession, even though it could not be the very one he wanted. The dental profession had just broken away from medicine and founded its own schools, and as this had some resemblance to his earlier desire, young Morton decided to take up dentistry.

At this period, dentistry left much to be desired. Dr. Chapin A. Harris, a founder of the first dental school, said in 1840: "The profession is crowded with individuals, ignorant alike of its theory and practice, and hence its character has suffered in public estimation—the calling of the dentist has been resorted to by the ignorant and illiterate and, I am sorry to say, in too many instances by the unprincipalled. . . ." This was none too severe an indictment, and it was only through the efforts of such men as Harris and Morton that dentistry was to survive as a separate profession and eventually become recognized as one of public necessity.

The Baltimore College of Dental Surgery was founded in 1840, and Morton was one of its first graduates. While there he met Horace Wells and after graduation they set up in partnership in Boston. As usual with such affairs there was not enough business for both and they separated, Wells going to Hartford and Morton staying in Boston.

At this time there were many lecturers touring the country who gave entertainments at the clubs and lyceums, where the natives of the smaller communities whiled away the winter hours. Among these was a Mr. G. Q. Colton, who came to Hartford and gave a demonstration and lecture on nitrous oxide or "laughing gas," as it was popularly known. When the gas is administered in an impure state the characteristic symptoms of exhilaration are quite amusing to an audience and his lecture was very generally successful. Dr. Wells was very much interested and induced Colton to give a private demonstration on December 11, 1844. At this time Wells noticed that the subject was immune to physical pain. This fact made him wonder whether or not he could use it for his purposes, so he voluntarily took the nitrous oxide and while under its influence he had a tooth removed by Dr. John M. Riggs. This is the first recorded instance of a surgical operation deliberately performed on an individual while under the influence of

nitrous oxide. Wells experimented during the winter and used his own patients as subjects. Early in 1845 he went to Boston to give a demonstration before Dr. John Warren's class of medical students. Owing to poor equipment or haphazard administration he was totally unsuccessful, for the patient cried out, the students jeered and Wells returned to Hartford discouraged and discredited. His lack of experience alone prevented him from being successful, but the entire matter so weighed on his high-strung mind that he retired from practice, and after a short stay abroad he committed suicide. This tragic ending, together with Wells's pleasing personality, did much to bring trouble on Morton's head at a later date. Wells should have all the credit that is justly due him, but if the world had been compelled to wait for some development to come from his work, there would have been a much longer period of time before the process was entirely perfected. As a matter of fact nitrous oxide was practically abandoned until G. Q. Colton resurrected the method in 1862.

Morton had assisted Wells at this fiasco and they must have discussed the subject thoroughly, but outside of the fact that Wells tried and failed at a public demonstration, while Morton tried and succeeded, there is no reason to believe that one helped the other to any great extent. The inhalation of fumes in medical practice was no new feature; in fact, ether was used in extreme cases of consumption and had been used as a local refrigerant at various times. Wells and Morton were working along the same lines and it is no wonder that it is difficult to assign credit definitely to one or the other, for they were associates and students together during the entire period, up until Wells's public demonstration. Morton had begun to work along different lines, and he drew as much inspiration from other sources as he did from Wells.

After the break in partnership, Morton had prospered, in fact, work came in so rapidly that he was compelled to hire several assistants. He had made several improvements in dental technique, and he was one of the best known practitioners in the city. His craving for a medical education still remained unsatisfied, so that in 1844 he entered Harvard Medical School. Morton was required to select one man from among the medical men of the city as preceptor or guide, and he chose Dr. Charles T. Jackson, then acknowledged the foremost chemist of the city and the one man most likely to help Morton in his work. The latter had not completely hidden the fact that he hoped to find some agent capable of deadening pain and Jackson had suggested sulphuric ether as a local application over sensitive tissue and they had discussed the properties of several other drugs at various times. Jackson claimed later that he knew that sulphuric ether would produce stupefaction when inhaled, but he did not make any such assertion publicly prior to Morton's demonstration.

The few known facts concerning ether impressed Morton and he set himself to determine all the properties of the substance. He read what little he could find and experimented with ether on small animals and on himself. It was customary for those that knew a little about ether to inhale the fumes up to the point where dizziness and a slight degree of intoxication was produced. This "ether jag" was well known among medical students and chemists and was practiced more or less openly. Morton tried to carry the state beyond the intoxication stage and at one time made himself deathly ill by inhaling the fumes of ether and opium together. His attendance at the medical school must have

been rather sketchy, for he was carrying on these experiments together with his dental practice at the same time.

On September 30, 1846, he administered the ether to one Eben Frost for the extraction of a tooth. The next day the Boston *Evening Journal* published a news item concerning this event. Morton then felt that he must give a public demonstration, so he went to Dr. John Warren, professor of surgery at the medical school, and asked permission to appear before the surgical clinic at the Massachusetts General Hospital. Warren had known Morton for some time and had a good opinion of the latter's professional attainments, so he readily gave consent. In this matter Morton showed that he was willing to jeopardize his reputation by appearing before the same group that had condemned Wells.

At that time the Massachusetts General Hospital was the largest and best in the city of Boston, and in addition to its size and convenience had a surgical staff that was second to none in the country. The building was an impressive structure, standing as it did near the Charles River, where the stately Bulfinch dome and granite columns at the entrance gave an air of dignity and eminence that was well upheld by the standards of medical practice of the institution. It was especially noted for the neatness and cleanness of the interior, a matter that was not as generally emphasized in the hospitals of that time as it is to-day.

The operating amphitheater was directly under the dome and presented a much different appearance than the tiled and aseptic rooms now in use. Around about the old room were large cases containing surgical instruments, while chairs and tables of curious and unusual construction were scattered here and there about the pit. The many hooks, rings, pulleys and other restraining devices that were to be found on the walls all testified to the necessary brutality of surgery of the period. The profound learning of Boston medical society was shown by the presence of an Egyptian mummy whose lugubrious countenance must have been an ever-inspiring spectacle in this den of horrors. The surgeons themselves were accustomed to come directly from their offices in all the glory of whiskers, stovepipe hats and frock coats, with their spare instruments in their pockets, for sterilization was as yet unknown and patients still died of "bilious fevers" and "humours." There were generally a crowd of medical students on the benches that sloped up in tiers from the pit, and their appearance could not have been very inspiring, for the students of that age were notoriously unkempt.

Warren had set the date for October 16, 1846, and there was to be a representative gathering of the surgeons of the city. There had already been much angry discussion as to the possibility of Morton doing what he claimed, and there was a considerable group that did not like him personally, for his rather shy nature and the fact that he was only a dentist or at best merely a medical student was not entirely in his favor.

There was great difficulty in getting an inhaler suitable for the occasion. As there was no precedent for this work, Morton was accustomed to administer the ether from a bottle with a long snout that was inserted in the patient's mouth and on which he sucked rather than by the administration of the ether with a mask over the mouth and nostrils as is done to-day. The instrument maker was not able to devise an appliance that entirely satisfied Morton and at last he took a hand and made something up to his own specifications. Warren was kept waiting beyond the time agreed upon, and he had about decided that Morton had failed him, so that he turned to his colleagues and said, "As Dr. Morton has not arrived, I presume he is otherwise engaged." Just then Morton came. The patient was willing

to have anything done to alleviate the pain and with few preliminaries the administration began. The spectators rather expected a repetition of the Wells fiasco but nothing unusual happened and the patient soon lapsed into a deep slumber. Morton turned to Warren and said, "Your patient is ready, sir"; and the operation was begun while an astounded silence fell on the room. Accustomed as the surgeons were to the struggles and torture of their patients, this seemed like black magic. Warren finished and broke the silence with, "Gentlemen, this is no humbug." Dr. Bigelow chimed in with, "I have seen something to-day that will go round the world." There should have been a prayer of thanksgiving offered up in the old Puritan town on that occasion if ever.

The news spread rapidly and Morton was called upon to administer the ether for many cases. There were many references to the discovery in the Boston and New York papers, at first quite complimentary, but soon there was criticism and doubt as to the merit of the preparation. Morton had added some aromatic oils to the sulphuric ether to disguise the odor, but he had told the surgeons at the hospital that the active agent was none other than the ether. There was nothing essentially wrong in Morton's conduct in this regard, for he had assumed an immense amount of risk in his experimental and practical use of the agent, and the unpleasant results that followed when the application was in unskilled hands only emphasized this point.

Unexpected opposition came from some of the clergy, based on the assumption that pain was the direct consequence of original sin and therefore must be endured. Morton was threatened with prosecution and there was general condemnation of this terrible drug that set aside the laws of God and man. Dire pictures were painted of the use of this drug by criminals and all the hysterical fire of misguided religious zeal was brought to bear upon the matter.

One clergyman wrote of ether as "a decoy in the hands of Satan, apparently offering itself to bless Woman, but in the end it will harden society and rob God of the deep earnest cries that rise in time of trouble for help." Such stupidity seems incredible, but there were to be even more serious attempts to discredit Morton. No scurrility was too harsh to be applied to him, and the half truths and slighting comment often came from his neighbors and professional associates, the ones who were the first to be freed from that intolerable agony of pain that had so long burdened the human race.

Following the custom of the time, Morton patented his discovery. There is no doubt but that he hoped to profit by his effort, and in any other branch of endeavor there would have been no objection. However, there has always been considerable feeling among the medical and dental practitioners that humanity had need of every process for the alleviation of suffering without let or hindrance, so that rights and patents held by any one practitioner are foreign to the spirit of medical justice. Be that as it may, Morton gave his formula freely to the Massachusetts General Hospital without charge and only intended to profit by the sale of the preparation, called "Letheon." But every one knew that he was using ether and there was no particular need of buying a patented preparation when the pure ether could be obtained from a chemist.

It is interesting to note that the physician-author, Oliver Wendell Holmes, in a personal letter to Morton suggested the use of a new term "anesthesia" to describe the state produced by the application of the drug. Dr. Holmes continued as a friend and supporter, and it was only through the help

of such men as Holmes, Warren and Bigelow that Morton was able to weather the storm that was about to break.

The opposition grew stronger within the first few months of the new year (1847), and the storm of protest and recrimination aimed at Morton fouled his fame and even to-day is responsible for the lack of appreciation of his work. The most abominable blow came from the members of his own profession in the form of a manifesto, published in the Boston *Daily Advertiser* and signed by Dr. J. J. Flagg and most of the leading dentists of Boston, making a formal protest against the use of ether and predicting all sorts of dire calamities from its use. This was to confront Morton at every turn and be used to discredit him when he went to other communities.

Cheap cynicism and irony were lavished upon the discovery by jealous medical men from less enlightened areas as follows:

Professor A. Westcott, of Baltimore, remarked that if Morton's sucking bottle would perform all the marvels accredited to it, the proper place for its use would be for squalling infants in the nursery; R. M. Huston, M.D., Philadelphia, "Quackery"; Wm. C. Roberts, M.D., New York City, "Humbug and a patented nostrum."

The editors of a New Orleans medical journal could not understand why the surgeons of Boston were captivated by such an invention, when mesmerism had accomplished a thousand times greater wonders.

It seemed as if the entire medical profession, outside of a few men in Boston, felt personally insulted that they had not been taken into confidence regarding this invention.

The efforts to discredit Morton are too loathsome to repeat. He was persecuted unmercifully, his dental practice broken up, his personal morals viciously attacked and every possible effort made to alienate any affection that his friends might have for him. The attacks were carried into his own home and he and his wife suffered endless humiliation. There was no limit to which his enemies would not go, and at times it was actually dangerous for him to appear in public. When he went to a small town near Boston to escape his persecutors, he was burned in effigy on the streets. Such humiliation is seldom the lot of him who has benefited mankind with one of the truly great gifts.

Dr. Jackson, his old preceptor, had been included with Morton when the patent was taken out. The attorney advised that this be done, for Jackson had prior knowledge of the work and that might have been sufficient to bring the originality of the discovery into question. Jackson had refused to be included at first, saying that he might lose his professional standing by taking out a patent on a secret preparation. This objection he finally withdrew, and when the patent was issued on October 27, 1846, Jackson was a co-patentee. Later Jackson was to claim the entire credit for the discovery in a letter to the French Academy of Sciences, and the final result was an extremely virulent quarrel between Morton and Jackson. The most that can be said of Jackson's claim is that more credence could be given to it if there were any record of his making a public statement concerning the properties of ether, prior to Morton's demonstration. If Jackson did know all about the material and its uses, as he very probably did, he was perfectly willing that Morton assume all the risk and responsibility for manslaughter that attached to the administration of the drug.

An application was made to Congress for recognition of Morton's discovery and to obtain an appropriation worthy of the work. The lawmakers were so hectored and flustered by the claims and

counter-claims of the partisans of Jackson and Wells that they were unable to come to a definite agreement; no credit was given to any one and Morton retired, poorer and more discouraged than ever.

There was an additional claimant at this time, one Dr. Crawford Long, of Atlanta, Georgia. He had seen ether used for jags and sprees, had experimented with it on some patients and, it is said, used ether for anesthetic purposes two years prior to Morton's public demonstration. The evidence is quite obscure on this, but Long himself admitted in the *Southern Medical and Surgical Journal* of December, 1849, that he had not progressed far enough to be sure of his ground. Such action as he took after the public interest in Morton's work would seem to be simply an effort to steal Morton's glory. Long abandoned his experimentation and certainly had no appreciation of the possibilities of the drug. He was simply one of the many others who had the chance to bring the hidden facts to light but was incapable of doing so. Sir Humphry Davy had written of nitrous oxide in 1800, that it was capable of producing stupefaction and insensibility to pain. The materials for all the discoveries that have blessed mankind have stood ready at hand since the beginning of time, but only those who are able to recognize and put the unknown to use should have credit as discoverers.

Wells and Long both deserved better fortune. Jackson has not a glimmer of justification in his claim. Morton succeeded where the others failed but reaped a whirlwind of abuse that was the most humiliating ever visited on a great pioneer.

The shoddy methods used to discredit Morton were entirely unjustified. The only considerable honor that he received in his lifetime was a gold medal from the French Academy of Sciences and an honorary medical degree from an American university. There is every reason why his name should rank with that of the great Americans, for to him must go the entire credit of risking his life and happiness in order that mankind be freed from pain.

The epitaph on his tombstone in Mount Auburn Cemetery at Cambridge best describes his lasting claim to fame:

Dr. W. T. G. Morton
Born August 19 1819.
Died July 15 1868.
Inventor and Revealor of Anaesthetic Inhalation.
Before Whom in all Times Surgery was Agony.
By Whom Pain in Surgery was Averted and Annuled.
Since Whom Science Has Control of Pain.

AN EXPLORER'S EXPERIENCE WITH THE GREENLAND GLACIAL ANTICYCLONE

By Professor WILLIAM HERBERT HOBBS

UNIVERSITY OF MICHIGAN

THE winds upon our planet are set in motion by extremes of temperature between the hot equatorial belt and two vast refrigerating areas which are located, one to the northward over the ice-dome upon the continent of Greenland, and the other to the southward above a similar dome which overwhelms the great Antarctic continent.[1] Of all Greenland explorers five only—Nansen, Peary, J. P. Koch, de Quervain and Rasmussen—have had personal experiences with the glacial anticyclone in both of its major aspects. These are: the calm interior region of excessive cold, and the contrasted outer slope region of violent down-slope winds alternating with occasional calms. Of the five explorers mentioned, two only—Dr. de Quervain, of Switzerland, and Colonel J. P. Koch, of Denmark—have penetrated far into the interior. The Swiss and the Danish explorers have each crossed Greenland from coast to coast near where the continent is widest. Their narrative accounts of these expeditions are closely in harmony, but the technical scientific report by Colonel Koch is not yet in print. It is for this reason that a popular article published in 1914 in the German language in *Ueber Land und Meer*[2] has great interest and significance.

This article appears to be practically unknown to meteorologists or others interested, and as the story told is set forth in clear and forceful language and is altogether the best account of such an experience that anywhere exists, the writer of this article has obtained the permission of Colonel Koch to publish the essential parts in translation.

The transection of the Greenland ice-dome was undertaken by Colonel Koch in the very early summer of 1913. He started out on April 20 from Danmarks-Havn near Cape Bismarck on the east coast in latitude 77°, and came down to the west coast at Upernivik in latitude 72° 30′. This expedition across a barren waste of eight hundred miles of snow and ice was undertaken solely for scientific purposes, and the party consisted of four men, one of them the eminent meteorologist, Dr. Alfred Wegener. For draft animals Icelandic ponies were taken, and the full story of the affection of the men for "Grauni" and the attempt to get this superb animal across to the west coast is one which is full of human interest but which must be left for telling in another place. In what follows we shall use the words of Colonel Koch's narrative in translation beginning with the departure from the east coast:

[1] W. H. Hobbs, "Exploration of the Poles of Wind on our Planet—Radio Talks on Science," SCIENTIFIC MONTHLY, Vol. 22, May, 1926, pp. 453–455. A technical account is contained in "The Glacial Anticyclones, the Poles of the Atmospheric Circulation," Univ. of Mich. Studies, Sci. Ser., Vol. IV, 1926, pp. 198, pls, 3, figs. 53. Sold by the Library of the University of Michigan.

[2] Captain J. P. Koch, "Die erste Durchquerung Mittelgrönlands, Erfahrungen aus der dänischen Forschungsreise 1912/13." *Ueber Land und Meer*, 30 Jahrgang, 1914, pp. 1721–1729 (with 12 illustrations).

The sledges stood in a row loaded and harnessed with the muzzles all turned to the westward. . . .

A sky covered with heavy gray clouds; only in the northeast a weakly glowing light which announced the dawning day; deep bluish tones in the east above the steep rock cliffs on the Mörkefjord, Hellefjord and Teufelkap; bright light yellowish-red colors in the west over the peaks of Queen Louise Land; complete calm, the flag over the "Borg" hung dead against its staff in mournful folds.

I gave the command for the departure. The sledges slipped forward without noise over the soft freshly-fallen snow. . . .

A light breath of wind wafted down from the north over the Storstrommen. The flag over the "Borg" opened out its folds, it nodded and waved to us with its threadbare fringed cloth.

That was the last greeting of our home to us.

It was a hard journey. Each day wind and snow—often stormy blows—and always against us. We learned to know it, this lashing drift snow which filled the air. It whirled up under the hoofs of the ponies and the runners of the sledges; it cemented itself firmly in the woollen cloth, the furs and the hair of the ponies. It penetrated into the skin and burned in the eyes, and we were forced to put on snow spectacles. It almost hid the sun, so that everything became gray in gray. One could no longer see where to place his feet and fell down in the hard furrowed snow, got up, groped about, slipped, and fell again.

In the long run this continual drift snow, which permitted us neither rest nor quiet, was unbelievably exhausting. At first we thought that we had ill luck with the weather. We were inclined to lie still if the drift snow was heavy, for we believed it was more economical to wait for good weather. It tired the ponies to draw the heavy loads in the blizzard; they became snow-blind, their eyes became inflamed and discharged pus. But gradually it became clear to us that wind and drift snow was the normal condition within the marginal zone of the inland-ice. If we wanted to advance over Greenland we must come to terms with the conditions as they really were.

On the 6th of May we passed the outermost nunataks toward the west. Now we had the land behind us and were spared the many curving detours which till now we had been forced to make. Before us lay the vast sea of snow of the interior of Greenland. We were upon the open sea, could lay our course in the same way as the mariner who steers his ship from coast to coast.

From this moment we went on with certainty and uniformly, though slowly—at the average rate of 15 kilometers daily. Exactly this speed which I had laid out in my estimates as fundamental in respect to provisions and fodder. In spite of this, because of its monotony, the journey was extremely wearying. Always the same blue-gray sky, always the same unchanging white snow surface, no clouds, no naked rock peaks which can interrupt the monotony and excite the imagination.

In the measure that we advanced farther, the wind fell off. In the middle of Greenland it became quite calm. The place of the snow drift was taken by mist, which usually in the morning would be so dense as completely to hide the sun. The air was over-saturated with moisture. Clothes, especially furs and stockings, were therefore constantly wet. Only in a few instances did we succeeed in drying them to a certain degree.

Yet the humidity never so got the upperhand of us as to become a torment. However, one shrinks from putting his feet into wet socks and kamiks[3] in order to keep warm. That was all, however.

The sun bothered us somewhat more. During the day it overcame the mist, and toward twelve o'clock it fell directly into our faces. We were high up. The barometer reading showed less than 500 millimeters. The air was so thin that it was unable to absorb the ultra-violet rays of the sun which act so injuriously upon the skin. One's skin burned therefore on the face and nose. The cheeks and lips especially became covered by quite painful blisters which exuded strongly. The cold struck into the wounds which made the situation naturally no better.

Each evening we rubbed our faces with vaseline; it did not help particularly. The wounds burst open, however. Tobacco and warm food we could not endure; it burned much too cruelly, and if, unfortunately, one was forced to laugh, the lips at once tore open. Two of us still carry on our faces the clear traces of the bad usage which we suffered.

I am endeavoring in fairness and as simply as possible and without exaggeration to narrate, and yet I have now doubtless conjured up a picture of four tortured men who dragged themselves forward over the high glacier full of bitter thoughts on all the suffering which they must endure.

Yet it was not so. Neither the wounds in the face nor the wet and frozen furs were anything other than the hardships in which one can easily

[3] The fur boots worn in Greenland.

find himself. No! far more were we four silent men who thoughtfully and quietly went forward over the inland-ice. An almost complete lack of anything happening makes for silence. The track of a fox on which we stumbled almost in the middle of Greenland, furnished us material for conversation for three days, and searching reflection also over the question whether perhaps land might be near. A snow sparrow which followed us over the inland-ice was looked upon as belonging to our company on the journey. When he had been away for a few days and we then heard him twittering in front of the tent, it was something so highly interesting that we communicated it to each other and carefully recorded it in our diary. During the march when our stupid little dog chased the snow sparrow, we put on our skis and excitedly followed this chase, whose possible result we were worried about. . . .

As we gradually approached the west coast we had the wind at our backs. We made sail on the sledges, and the journey now went so easily that we no longer needed the pony (only one, Grauni, remained at this time. W. H. H.). We tied him on behind the sledge and let him trot along behind. . . .

Naturally, Grauni did not have enough to eat; we hoped, however, that he would go on. We required indeed no work from him. He was now our passenger and was towed behind the sledge. When he became tired or we were going too fast, we laid him on the sledge on our sleeping bags, spread out the tent over him, and tied him comfortably but securely on the load. There he lay and had obviously a fairly good time while we others drew him.

It goes without saying that in this way the load was heavy. We had, however, the wind at our backs and were going down slope so that the sledge often slipped along quite easily. Now and then Larson sat up in front upon Grauni as the steerer of the sledge and I behind as conductor, and so we sped on down the slope for kilometers with the speed of an express train, while Wegener and Vigfus who followed behind on skis, remained far in the rear.

In the outer part of the marginal zone we encountered the usual hardships; deep snow powder, sharply angular and lumpy ice, turbulent streams of water within deeply cut trenches, and, further, glacier cracks.

After all these efforts to bring Grauni across Koch was finally compelled to shoot him. As a whole the record is a remarkable one and reflects the very greatest credit upon the leader, distinguished alike for courage and fortitude, for far-seeing perception of the fundamental scientific problems involved, and, not least, for a kindly interest in the four-footed but devoted members of the expedition. As stated above, this terse account supplies the best statement based on personal experiences that we have of the essential nature of the glacial anticyclone of Greenland.

OUR AMERICAN FORESTS, THEIR PAST, PRESENT AND FUTURE

By Dr. RAYMOND J. POOL

THE UNIVERSITY OF NEBRASKA

ONCE upon a time a weary nature-lover, threading his way through the magnificent forests of the land where rolls the Oregon, sat himself down to rest in the cooling shade of the mighty denizens of that woodland wonderland. The springy litter and the soily, soothing aroma of the vast forest solitude brought instant relief to his muscles and joints, wearied from strenuous climbing, and he fell asleep.

He dreamed that he lived in a goodly land, stretching from ocean to ocean, and among a people the most blest of all mankind. In that land there were wonderful, far-flung forests containing scores of different kinds of trees, each one fitted for a particular use by the citizens of his native land. But his people had been very unwise in the use of the forests that nature had nurtured through the ages, and the vast sylvan heritage was devastated ruthlessly. Three centuries of forest despoliation had offended the gods who rule over the destinies of the woods and they met in the forest near our sleeping naturalist that day in tumultuous protest against such wanton disregard of nature's masterpieces. They were to decide what should be done in order to put a stop to the awful, ever-spreading desolation that had swept across the fair land. Vigorous and effective action must be taken if the land of great waters and of noble wild things was not to be plunged into dire distress for want of an adequate supply of wood and other forest products for future generations.

The debate was loud and long, but at last it was decided by the great host of ethereal beings that from that day each and every tree, of whatever kind and wheresoever it might be in that land, should bear aloft a burnished golden crest. The crest was to proclaim to all mankind something of the meaning of trees and of forests in the economy of nature and of their essential contributions to the continued happiness and advancement of the human race.

At this point, pungent whiffs of resinous smoke from a nearby forest-fire reached the traveler and he was half awakened. As he turned slowly about he noted that every tree in that vast shadowy woodland, from the tiniest seedling to the greatest and oldest of the giants near him, bore the golden crest so recently bestowed with such regal pomp and circumstance. And as he read the words emblazoned there he mused upon a warning said to be displayed on the trees in a certain far-away nation that was once rich in the affairs that make for progress in human endeavor. That nation had deteriorated sadly and was now but a ghost of its former self. The warning which the guardian hosts had left with their representatives in the material world ran somewhat as follows:

Ye who pass by and would raise your hand against me, hearken ere you harm me.

I am the heat of your hearth on cold winter nights, the friendly shade, screening you from the summer sun, and my fruits are refreshing draughts quenching your thirst as you journey on.

I am the handle of your hoe, the door of your homestead, the wheel of your carriage that takes you hither and yon.

I am the beam that holds your house, the board of your table, the bed on which you lie, and the timber that builds your boat.

I am the flimsy sheet upon which you trace the boastful record of your past, and design your uncertain plans for future years, the gossamer tissue with which you garb your passing beauty.
I am the wood of your cradle, and the shell of your coffin.
I am the thread of kindness and the flower of beauty. Ye who pass by, listen to my prayer, and harm me not.

The wayfarer was now fully awakened and greatly refreshed. He resumed his journey as the lengthening shadows crept across the well-beaten, mossy trail. His thoughts were occupied with the dream, and with a review of certain features of the scientific and economic history of our nation that are familiar to few Americans.

When white men first came to America, the area that has become the United States was endowed with superb forests, the equal of which has never been known in any part of the modern world. There were magnificent stands of pine and spruce and hemlock and maple in the Northeast and in the Great Lakes country; of walnut and hickory and poplar and oak and chestnut on the Appalachian plateau and on the Ohio. In the South, the beautiful, park-like forests of yellow pine and swamps rich in cypress and gum awaited the march of civilization. The vast domain of the Rocky Mountains, with its ruffled blanket of evergreens, had not been devastated by recurring fires, and the sylvan splendors of the redwoods and the Douglas fir of the Pacific Coast had not yet been disturbed by man's lust for gold.

It has been estimated that the original forests of the United States covered 822 million acres and that these stands contained the enormous volume of 5,200 billion board feet of lumber.[1] Some five hundred different kinds of trees have been described from these forests. Thus we may understand that the American people are, by inheritance, a nation of exceeding richness in the matter of forest resources and forest influences. Nature has blest us with an unusually rich and varied heritage in the matter of direct forest products, not to mention specifically any of those well-known esthetic and intangible relations that are inherently the attributes of great tracts of woodland.

But from earliest colonial days we have practiced a form of tree-butchery and forest-devastation that, from the very beginning, has threatened the stability and the permanency of this vast storehouse of indispensable national supplies. Our treatment of our forests has been nothing short of disgraceful and shameful.

Two thirds of the original forest area of 822 million acres has been lumbered, culled or burned. Three fifths of our original timber supply is gone. There are to-day in the United States about 135 million acres of virgin growth forests ready for the lumberjack, and about 113 million acres which are only poorly stocked with more or less inferior trees. Our inheritance of 5,200 billion board feet of timber from the forest primeval has been reduced to about 2,200 billion board feet of merchantable timber. And we are yet a very young nation! The most unsightly blot of the whole unfortunate exhibit is represented by the eighty million acres of land, once covered by valuable forest, which are now devastated and must be classified as waste land. What a hideous mockery of American thrift!

The whole unpleasant story of forest wastage in this country during the past three hundred years sounds much like the classic selection from the old reader on how to tell bad news. The forest was an "ever-present and a far-flung menace in the minds of the early settlers." It

[1] I am pleased to acknowledge my indebtedness to the following publications for many of the estimates used in this article: Greeley, "Timber Depletion and the Answer," Dept. Circular 112, U. S. Dept. Agr., 1920; Brown, "The American Lumber Industry," Wiley, 1923.

was spread over the areas badly needed for beans and tobacco and maize. Wild beasts and even wilder and more dangerous men lurked threateningly in its shadowy depths. It is perhaps not surprising that our forebears felt the necessity of clearing off the forest, and even doing it ruthlessly, when they regarded it as such a powerful obstacle and when they believed that the timber supply was inexhaustible.

A few wide-awake American citizens (a pitifully small company) now know how faulty those notions were. Not only are the forests gone, but most of an important host of remarkable game and fur-bearing beasts have gone with it. The same relentless pursuit has coralled the last miserable herd of the buffalo and the carrier pigeon has been exterminated. We have been told that our splendid accumulations of nature's fuels and other minerals have been greatly reduced. Large cities in mining districts of the west, once buzzing and throbbing with the life of a unique period of our history, have been depopulated within a generation. We are aware, if we have looked into this matter at all, that our natural resources may be exhausted and that the end of some of them is already in sight. The last areas of our once vast stands of virgin forests are now being leveled at a startling rate.

The sad fact is that the "average American citizen" has been, and is today, too busy "selling" his nation and its natural resources, which are the rightful possession of the whole body of citizens, to stop to ponder about an adequate supply of essential natural resources to meet the constantly increasing and varying demands of the generations of Americans who are to people our states in future centuries. He is likely to take the attitude of the early colonists that such resources are unlimited, so why should he waste any time worrying about the requirements of posterity.

We are using up our forests at an astonishing rate to-day. Foresters tell us that the cutting and loss of merchantable timber represent a volume of fifty-six billion board feet each year. About forty billion feet of this is secured from the virgin forests still standing, and the rest comes from second-growth forests. Our pulpwood, acidwood and fuelwood demands consume fifty-five billion board feet per year, and the most of this wood comes from material too small or for other reasons unfit for the saw. Only about *six billion cubic feet* of wood are *growing* in our forests each year, but we are *removing,* all told, about *twenty-six billion cubic feet* of wood from these forests each year. Recent estimates indicate that our supply of soft-wood timber is being cut 8.5 *times* as fast as it is growing. Trees that are too small for the sawmill, upon which the future supply of timber depends, are being used 1.5 *times* as *fast* as they are *growing.* These are the most stupendous and startling facts that come from a study of the present forestry situation in the United States. We need go no further in our search for a reason why every man, woman and child and every organization of the people of our nation should become everlastingly enthusiastic for the early development of a forest policy that will insure adequate reforestation and the improvement of our remaining forest resources and their perpetuation for all time.

Our annual demands upon the forest call for upwards of thirty-five billion board feet of lumber; one hundred and fifty million railway ties (a single tie contains thirty board feet of wood); six million cords of pulpwood (a third of which is imported); one hundred and ten million cords of fuelwood; five hundren million fence posts; one hundred and seventy million cubic feet of round mine timbers; eight million pieces of poles and piling; and one hundred million board feet for excelsior.

There are many other demands for wood in small unit pieces that pass our notice, but which in the aggregate represent a very large volume. It is said that we use each year nearly ninety million board feet of wood for matches and toothpicks. This volume of wood represents the annual increment in a forest of eight hundred thousand acres. Recently we have heard much about the manufacture of "artificial silk," "rayon," "lustron" and "celanese," etc., as another new channel of activity which will consume an ever-increasing quantity of wood. Already this cellulose-silk industry has developed four different processes of manufacture, and it has been estimated that the total output of these materials for the current year will reach two hundred million pounds.

On the whole it appears that the *annual consumption* of *lumber* in the United States a short time ago was about *three hundred board feet* per capita, and that the *total* consumption of *wood* was approximately *two hundred cubic feet* per capita per annum.

These few data clearly indicate that we are using enormous quantities of wood each year, and it would appear that the volume can not be reduced to any important degree without calling forth very serious reactions in the agricultural, industrial and home-building activities of the United States. The enormous, unnatural, economic tension of the past ten years brought our per capita use of wood down to the point where the country has suffered severely. All this has resulted in the well-known shortage of houses to meet the increased population-pressure of a decade and has occasioned a serious reduction in the output of many industries. With the astounding, nation-wide revival of building operations during the past two or three years, our present per capita consumption of lumber may have reached the alarming total of four hundred board feet!

The above figures are amazing when we compare them with per capita data from various European nations. We find that our consumption of lumber is from 500 per cent. to more than 1,000 per cent. greater than that for the more prominent countries of Europe. In view of this situation we sometimes wonder how long it will be until we too shall be forced to look upon lumber as a very expensive, imported luxury. And when that time comes, we wonder from what sources the imports will come. Prohibitive prices would seem to render large-scale importation of lumber economically impossible now or in the future. Therefore it is all the more imperative that the United States plant and grow its own great bulk of timber supplies.

Our country would suffer irreparable stagnation and damage if we were compelled at the present time to reduce greatly our annual per capita use of wood. Nevertheless, in spite of this very evident situation, we hustle along, unthinkingly, and the ratio of use to production of wood becomes more and more disturbing to a few of our citizens who are most keenly aware of the serious complexity of the problems involved.

In the face of this situation it should be an easy matter to shape public opinion to such a degree that the devastation of our forests and the wanton waste of forest products would be stopped at once. But progress in this matter is discouragingly slow when we think of the rapidity with which many such resources are being exhausted. For instance, the depletion of timber supplies in the United States has resulted more from the *devastation* of our forests than by their *use*. It is difficult to get the great mass of our people vitally interested in the one greatest factor in such devastation, namely, *fire*. Twenty-seven thousand forest fires have been recorded in a year in the United States, not at-

tempting to estimate the number unrecorded. These fires burned over eight to ten million acres of forest land. A single forest fire in 1918 destroyed $30,000,000 worth of timber and other property, and cost four hundred human lives. There were ninety thousand forest fires during 1925! More than two thousand forest fires occurred in a single western state in 1925, resulting in a loss of nearly $900,000. These would be considered tremendous sums of money if they were to be appropriated by legislative bodies for some specific public purpose, say for education.

The great majority of forest fires are caused by human agency, by you and me, if you please, and therefore it would seem that they should be easily prevented. But we don't know, or we don't care, our forests are inexhaustible! A famous forester has stated that 99 per cent. of the forest fires which occur in one of our great timber states are preventable. Lightning seems to be the only unpreventable cause of forest fires.

A great forest fire is a tremendously spectacular affair, but most persons think only of the immediate damage done to the trees by such a fire. The burning down and the scarring of the century-old veterans of the forest are, of course, deplorable effects which are at once evident, but there are many other serious results of forest fires. Forests are often burned over more than once by light fires. The cumulative effect of such repeated fires is well known. This is made evident in reduced growth-rate and in predisposing the trees to attacks from various insect and fungus pests which appear to lurk in the forest awaiting such opportunity. The destruction and the dwarfing of the young growth, upon which the future of the forest is dependent, is one of the most serious consequences of forest fires.

The destructive and desolating effects of forest fires are not limited directly to the trees of the forest, since in many cases the soil is burned and the watershed occupied by the forest becomes greatly modified. All this may lead to excessive run-off, more rapid streamflow, destructive erosion and damaging floods in lowlands far beyond the forest-covered areas. Such conditions as these are well illustrated in a very striking degree in a number of important localities in western United States as well as in many other parts of the world.

Fire is the most dangerous and discouraging factor in the way of successful reforestation in our vast areas of forest land which have been so ruthlessly stripped of their most valuable products. Fire-exclusion must be a cardinal principle of the working plan that is to be at all adequate in the long, laborious and expensive process of bringing the forests back to our deforested lands in all parts of the United States.

Another very unfortunate and serious economic feature of the forestry situation which we have inherited from the past (because of the absence of a wise policy of forest protection and utilization) is seen in the fact that the most important stands of our most valuable timber left are not in the right place. By this we mean that our remaining timber areas, of major importance, are on the rim of the nation, at great distances from our densely populated centers. Forest products flow into such centers only after journeys of several hundred or even thousands of miles and at an enormous cost for freight.

One great eastern state is now paying more than $25,000,000 each year for freight on lumber brought in from other states. The same state pays upwards of $50,000,000 per year, apart from the freight, for lumber which it imports. This is a sad commentary on the much-

talked-of business sagacity of Americans, especially when we understand that originally this state was extremely rich in forests, and that it could have maintained practical independence for all time, in so far as a lumber and wood supply of great variety is concerned. There are many other losses to the state on account of the local forestry situation, so that it has been estimated that this state suffers a loss of $100,000,000 annually, mainly because it failed to establish a satisfactory forest policy years ago.

Foresters tell us that New England retains less than 5 per cent. of her virgin forests and only about 12 per cent. of her original stand of timber. New York State, once exceedingly rich in forest resources and the leading lumber-producing state of the nation, now supplies less than one tenth of the demands of her cosmopolitan population. Pennsylvania, the leading lumber-producing state in 1860, now manufactures annually less lumber than is used in the Pittsburgh area. And so the movement of this great industry has gone, from the northeastern United States in 1850, to the great white pine areas of the Lake States, thence a little later to the famous yellow pine district of the southern states, where it remained about a half century. Finally it has hurdled the "Great Divide" to the Pacific States, and there the last episode of the picturesque drama (or tragedy) of the lumber industry of the United States is now being enacted, in so far as virgin forests are concerned. This last episode is the most feverish and tremendously impressive of the whole cycle. The entire movement has consumed a very brief time as compared to the span of life of many of those giants of the western forests which are now falling under the saw!

Where shall we go next? It's a long, long way to Siberia or to South America or to the Philippines; besides it would take us many years to adjust ourselves to the use of the woods from those lands, even if we might get them.

From that little old saw mill in Maine or Virginia, with a daily output of five thousand feet of lumber, to the modern, log-devouring behemoth, with a daily output of eight hundred thousand feet or more, has been a scant three centuries. The westward march of the lumber industry, briefly noted above, has taken place in three fourths of a century. What is three hundred years in the life of a forest! And what is seventy-five years in the life of a tree! Millions now living will live to see the final exhaustion of our vast original inheritance of virgin forests. It is surely time we were all impressed with the necessity of giving our trees a chance or soon, very soon, as the life of the forest goes, we shall have completed the despoliation begun by our forefathers and wrung the neck of one of our greatest industries. This industry now ranks third among those tremendous businesses which have been so important in making the United States of to-day great.

In the face of the regrettable abuse of our forests, only a few of the features and consequences of which have been noted in the preceding paragraphs, we are compelled to admit that we do not as yet have a public or private policy which seems adequate to insure the recovery of the ground that we have lost. So far we have met with but little success or encouragement in working out plans for the prevention of still further destruction, devastation and waste.

We are not a nation of foresters. The nation has not yet developed a forestry conscience. Forestry is scarcely a quarter-century old in this country. It will be many, many years before we shall have mastered an intimate knowledge of our forest trees and our forests, and the complex economic and social factors involved in their exploitation. But these

are fundamental prerequisites for the development of a scientific program of forest management and a forest policy worthy of the name. Nevertheless, it is to be hoped that we may yet somehow succeed, some time, in restoring extensive forest areas which at least may be reminiscent of our primeval wealth of forest resources. Surely we may also hope to perpetuate for all time, and in continually improving form, those really magnificent forest resources and influences which still remain in certain portions of our land. It is yet comparatively easy for us to lay the foundation for such a fine program, with nature's able help. We can do this if the nation can only focus its attention upon the essentials of the stupendous problems involved before it is forever too late.

We must, as a nation, set going the machinery that will stop the appalling loss and waste of forest products and bring an end to forest devastation. We must discover how to bring back the forest to the vast expanses of the public domain as well as to privately owned lands which have suffered the loss of their forests. We must provide for a more complete scientific investigation of the life-histories of all our important tree species and of the forest types which they form, together with an analysis of the climatic and soil conditions under which they develop. We must also speed up and complete the careful survey and classification of our forest assets which has been under way for many years. Effective legislation must be secured in order that all this may be speedily accomplished on a scale which amply meets the requirements of the nation.

In this way we shall become the creators of a new and vastly important epoch in the history of the development of the industries and the institutions upon which the future of mankind depends. In the words of our President:

> Let us apply to this creative task the boundless energy and skill we have so long spent in harvesting the free gifts of nature. The forests of the future must be started to-day. Our children are dependent on our course. We are bound by a solemn obligation from which no evasion and no subterfuge will relieve us. Unless we fulfill our sacred responsibility to unborn generations, unless we use with gratitude and with restraint the generous and kindly gifts of Divine Providence, we shall prove ourselves unworthy guardians of a heritage we hold in trust.

Let us stop the waste of forest products!

Let us stamp out forest fires!

Let us use our remaining forests wisely!

Let us plant forests!

Let us know our trees and our forests!

Let us give our trees a chance!

THE NEED FOR GAME FISHERY INVESTIGATIONS

By Professor NATHAN FASTEN

OREGON AGRICULTURAL COLLEGE

The last century witnessed so many new discoveries of a practical character that there resulted a complete transformation in our entire social organization. The perfection of the telephone, the telegraph, the automobile, the steamship, the factory, the radio, and the many, many other useful tools of our present civilization have not only completely overthrown the old order of things, but they have also radically interfered with the balance of nature to such an alarming degree as to bring about the rapid depletion or extinction of many of the most important inhabitants of our fields, forests and streams.

The game fishes have suffered perhaps as much as any of the other useful organisms. Factory pollution, irrigation dams, disease, the development of highways and a host of other similar circumstances have contributed towards bringing about such a rapid decrease in these forms that many of our choicest species have been threatened with complete extermination. Man has long ago recognized this situation and in order to overcome it he has developed the artificial hatchery for the sole purpose of developing, rearing and distributing the fish to the depopulated areas.

The average person thinks that our game fishery problems have been completely solved by the hatchery, but the thoughtful student of the question is not quite so positive of the results obtained. The fact is that we have been hatching, rearing and distributing fish for a good many years and yet it is no exaggeration to state that we have accumulated almost no positive knowledge which would warrant our making conclusive assertions along any of the lines of game fishery practices. There are a great many problems connected with the propagation of game fishes, and some of them ought to be carefully investigated, in order that we might go about the business of developing these valuable animals in a little more intelligent manner.

Where would agriculture, forestry, medicine, engineering or any of the other applied sciences be without the aid of the scientific research worker? Would progress be possible? And yet how different it is in the field of fisheries, particularly that branch which deals with the game fishes. Here there are exceedingly few scientists who are devoting their attention to the innumerable questions of importance which are awaiting solution. While in exceptional instances some effort has been made to secure the services of competent authorities, yet in the vast majority of cases the rearing and conservation of the game fishes has been entrusted to individuals who, although efficient as business men of affairs, nevertheless lack the adequate scientific training which would enable them to carry on experiments that would yield results of far-reaching practical importance. Sooner or later we must come to realize that we can best conserve our resources by knowing and controlling the factors which insure success. Such knowledge can only come through painstaking investigations running over a good many years. In an effort to stimu-

late research along this line, I have tabulated some of the salient problems which might lend themselves to analysis and would result in great benefit to our game fishery resources.

(1) A complete survey of the game fishes of each state, emphasizing such points as distribution, native forms, introduced species and particularly the effects of the latter on the native types. This study would indicate to a state game commission which kinds of species it ought to concentrate its attention upon. In many states there exists the practice of bringing in foreign species of game fish in the hopes that they will adapt themselves to the new localities and afford a source of enjoyment to the sportsman. In numerous instances this has proven to be a costly experiment, because the introduced forms not only killed off the native types but also proved to be a great deal less desirable than the latter ones.

(2) A thorough examination of the present methods of hatching for the purposes of determining whether improvements were not possible. Many of the methods in practice have been in vogue a good many years without change. Are they good, bad or indifferent?

(3) The foods which are most suitable for young fry, particularly of trout fry. At present there is no adequate knowledge upon this subject. Carefully planned experiments ought to be conducted to determine what are the best types of foods for the growth and development of the young fry which are reared under the artificial environment of a hatchery.

(4) The effects of extremes of temperature on the spawn of game fish. In order to shed some light on this question, accurate records ought to be kept on the differences in the mortality rate of normal fertilized eggs which are allowed to undergo immediate development and those in which development was delayed through the agencies of cold storage or freezing.

(5) The best methods of transporting fry over long distances. At present the two serious difficulties in such transportation are (1) the rise in the temperature of the water surrounding the young fish and (2) the depletion of its oxygen content. Can one through experimentation devise suitable means of overcoming these difficulties?

(6) The actual effectiveness of our fish-planting operations. Here ought to be included such points as the best age for planting of the fry and what percentage of them actually survive and reach maturity.

(7) The migrations of game fish, particularly those of trout, are other topics of great importance which ought to be investigated. Many sportsmen feel that in numerous streams which have an outlet to the sea, trout, even though they are planted in the upper head-waters, hundreds of miles distant from the sea, will sooner or later migrate down towards and ultimately enter the salt water, never to return to their former abodes. They think that this reason accounts for the scarcity of fish in many of these streams.

(8) The inauguration of comprehensive surveys of the various lakes and streams in which trout and other game fish are planted, in order to determine whether conditions are suitable for success. At present the planting is done in any body of water that looks good to the naked eye. Assuredly we ought to know a great deal about such factors as available food supply, oxygen content, temperature variations, predatory and parasitic organisms, etc., of a place before any kinds of animals or plants are introduced into it. Knowing these conditions, we can then intelligently fit each organism into that particular environment where it will thrive best. But without this knowledge we are simply

groping in the dark and are powerless to do any real good. These surveys can be carried on simultaneously with some of the other problems mentioned.

(9) The actual effects produced by the closing down of lakes and streams for long periods of time in order to give the depleted fish population an opportunity to multiply and repopulate itself. In many instances it is certain that such a procedure is distinctly detrimental because, in the first place, the fish begin to multiply so rapidly that there soon comes a period when there is not enough food for each of them, and this results in a fierce struggle for existence. Then again, various fish-eating birds and mammals build their nests along the shores of the closed waters and these not only kill off many of the desirable game fish, but they may also act as agents in spreading disease amongst them.

(10) The diseases of game fish and their prevalence in our streams and hatcheries. Here should be included life-history studies of the various parasitic organisms which attack the fish, with emphasis on control measures. The penning up of immense numbers of fish within the limited confines of a hatchery makes it relatively easy for disease to secure a foothold, and this invariably results in the death of a large number of fish.

(11) The conditions of water, soil, climate and the like, which are most conducive to successful hatching operations. Such knowledge would serve as a practical basis for guidance in the establishment of new hatcheries and would also be helpful in advising those citizens who contemplate going into the private hatchery business.

(12) The breeding of game fish, particularly of trout, for purposes of producing types which would have more desirable qualities than the original parent stocks.

These are some of the lines of investigation which would yield results of importance to our game fisheries. To carry them out it would be necessary for every game commission to have not only adequate laboratory facilities, but also a staff of scientifically trained investigators along these particular lines. Every state is face to face with the problem of its declining game and fish resources. The development of good roads and the possession of high-powered automobiles have had the desirable effect of bringing more people out into the open in search of the recreational opportunities afforded through hunting and fishing. But the fact which must be borne in mind by all readers is that the successful business of developing and rearing game fish under artificial conditions depends not only on the possession of suitable hatching plants, but also on some knowledge concerning the life-histories, habits, adaptations and adjustments of these particular organisms. Such a fund of knowledge can only be acquired through the patient and painstaking work of trained scientists, running over a period of many years.

THE PROGRESS OF SCIENCE

By Dr. E. E. Slosson

Director of Science Service, Inc., Washington, D. C.

THE NOBEL PRIZES

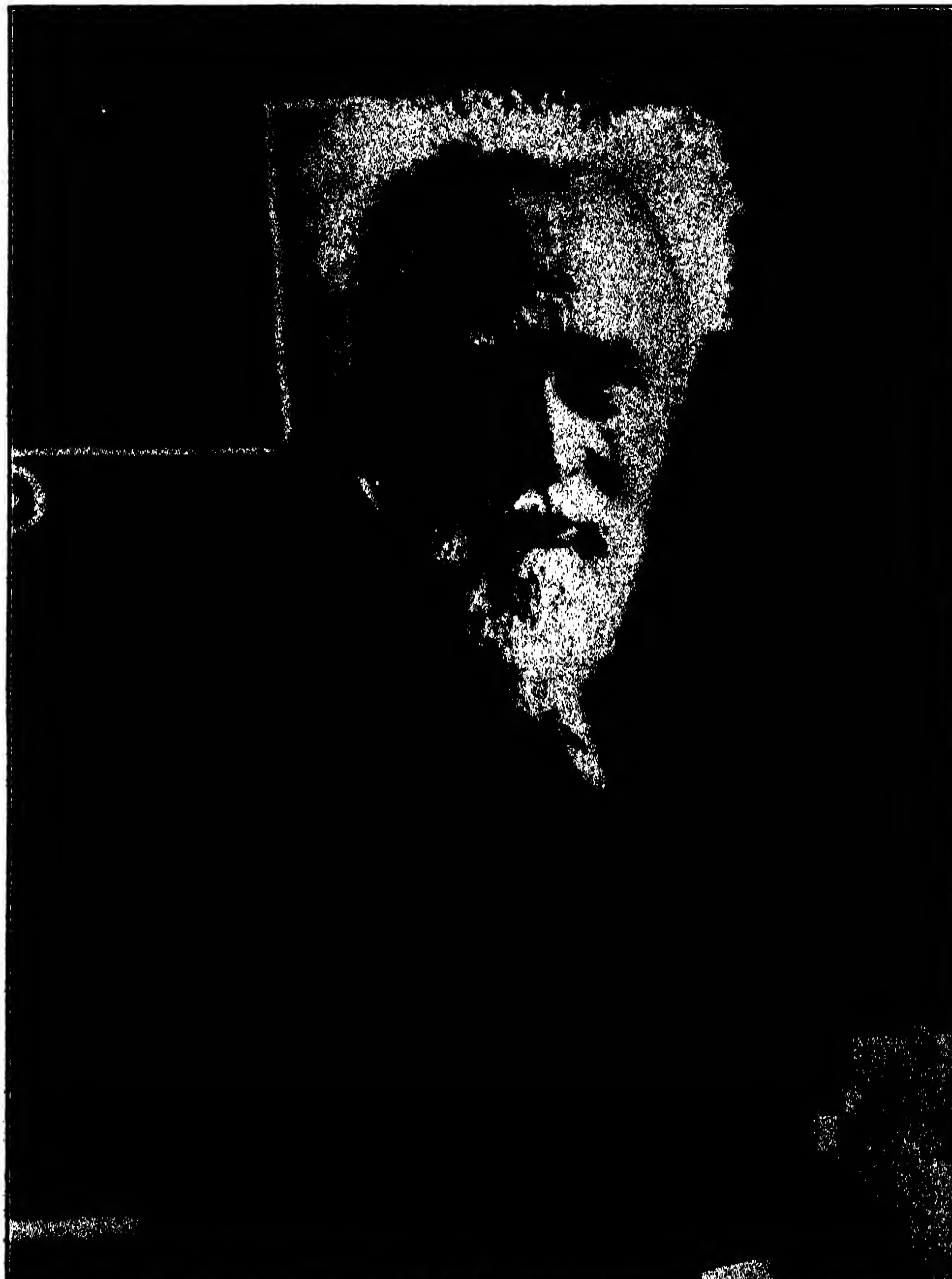
Nobel prizes were presented to five men of science by the King of Sweden on December 10. Germany maintains its leadership in the number of scientific men worthy to receive the prize, as many in physics and chemistry going to that nation this year as have to the United States during the twenty-five years of their history.

The University of Göttingen claims the distinction of two of the latest prize winners. Professor Richard Zsigmondy, who has received the 1925 chemistry award, did important work in the development of the ultramicroscope which he utilized in determining the size of the minute suspended particles of colloidal gold. The work for which Dr. James Franck, now at the University of Göttingen, and Dr. Gustav Hertz, of the University of Halle, who divided the 1925 physics prize between them, are best known in scientific circles was performed while they were associated at the University of Berlin. This was the first proof of the validity of the quantum theory, which was proposed originally by Max Planck and has caused a revolution in physical science in recent years, by proposing that light and other forms of radiation are not continuous wave motions, as was formerly thought, but consist of separate bundles or "quanta" of energy.

Franck and Hertz presented their now historic paper before the Berlin Physical Society in 1912. They found that if an otherwise evacuated tube contained a small amount of the vapor of mercury, and that if two pieces of metal or electrodes were sealed within so that the atoms of the vapor could be bombarded by rapidly moving electrons, or particles of electricity, a line corresponding to a certain wave length of light appeared when the glow of the tube was analyzed with the spectroscope. But this only occurred when a definite voltage was applied, which meant that unless the electrons were moving with a certain minimum speed, the particular wave length of light was not given off from the glowing mercury vapor. At the time, Professor Fritz Haber, greatest of German chemists, is said to have remarked that "this paper will be fundamental in the progress of physics," a prediction which has been amply fulfilled.

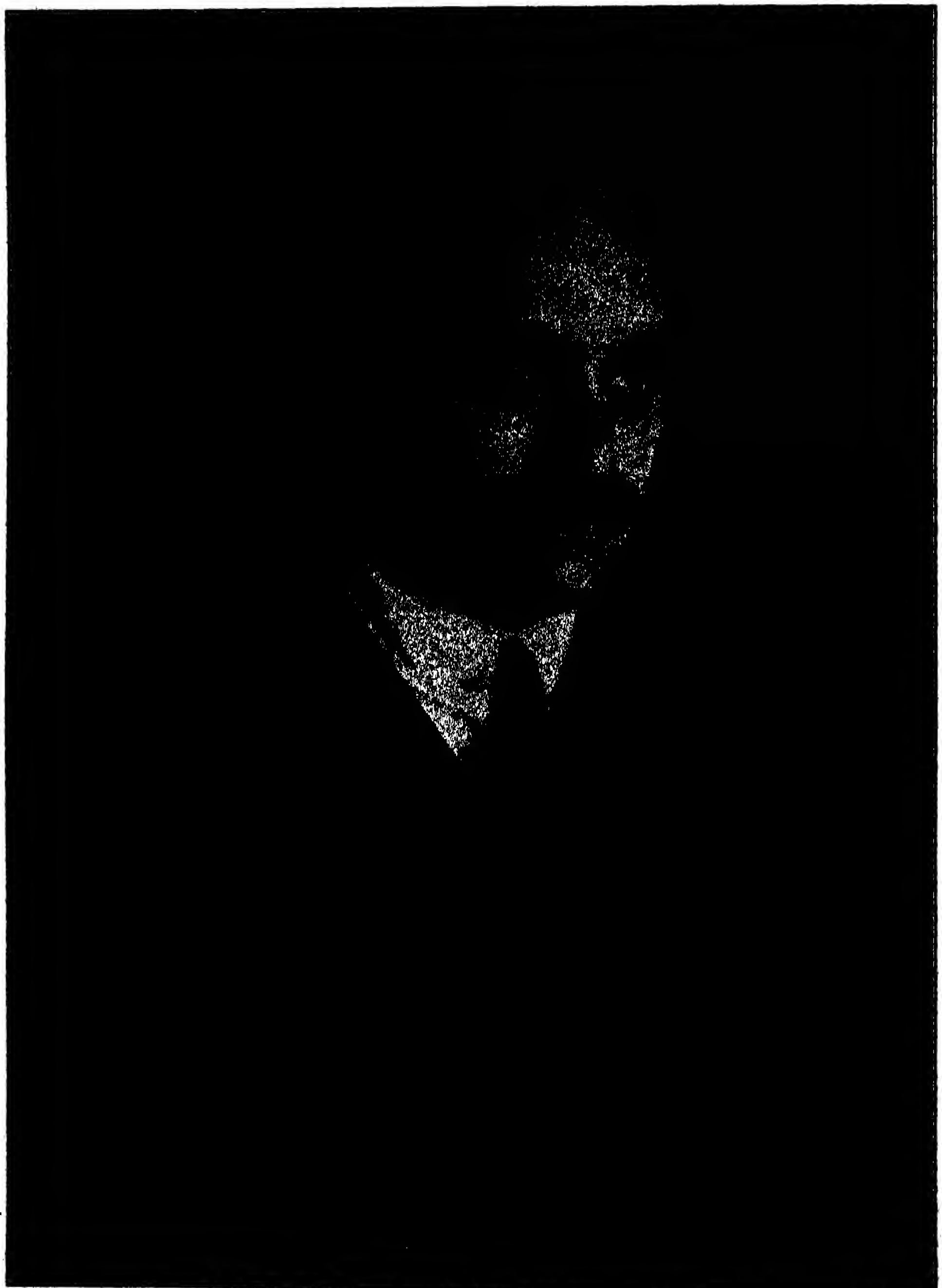
Dr. Theodor Svedberg, recipient of the 1926 chemistry prize, is an outstanding figure in the realm of colloid chemistry. He was recently invited to come to the United States to attend a symposium on colloid chemistry at the University of Wisconsin, and remained long enough to give a course of lectures to students at that institution. He has since returned to the University of Uppsala in Sweden.

Professor Jean Baptiste Perrin, of the Sorbonne, University of Paris, and winner of the 1926 physics prize, is well known to scientists for work done on the Brownian movement, the name given to the rapid oscillatory motion of minute particles suspended in liquids. Professor Perrin developed ingenious methods for measuring this movement which showed that the tiny particles behave in the

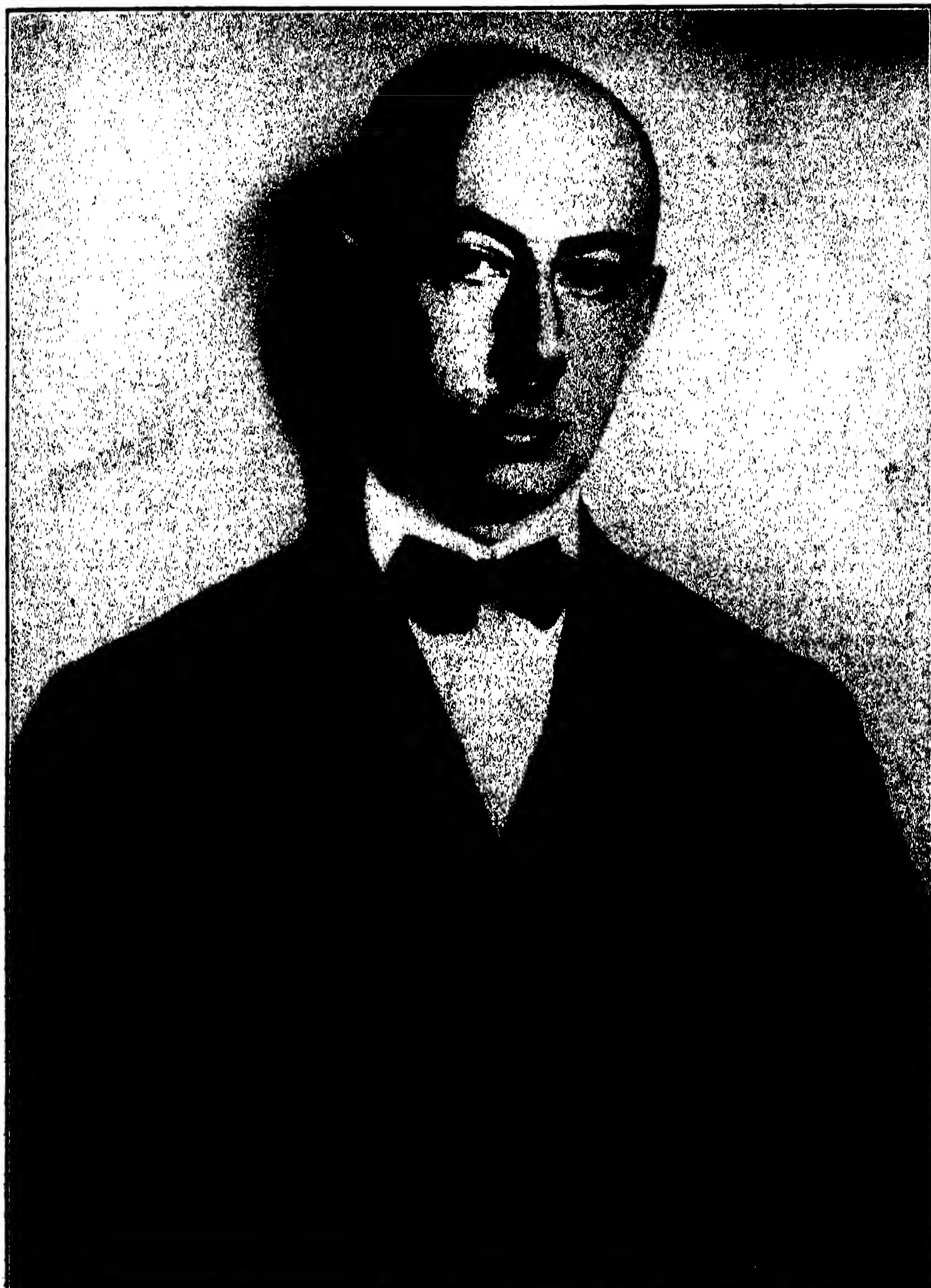


PROFESSOR JEAN BAPTISTE PERRIN

UNIVERSITY OF PARIS, WHO HAS RECEIVED A NOBEL PRIZE IN PHYSICS.

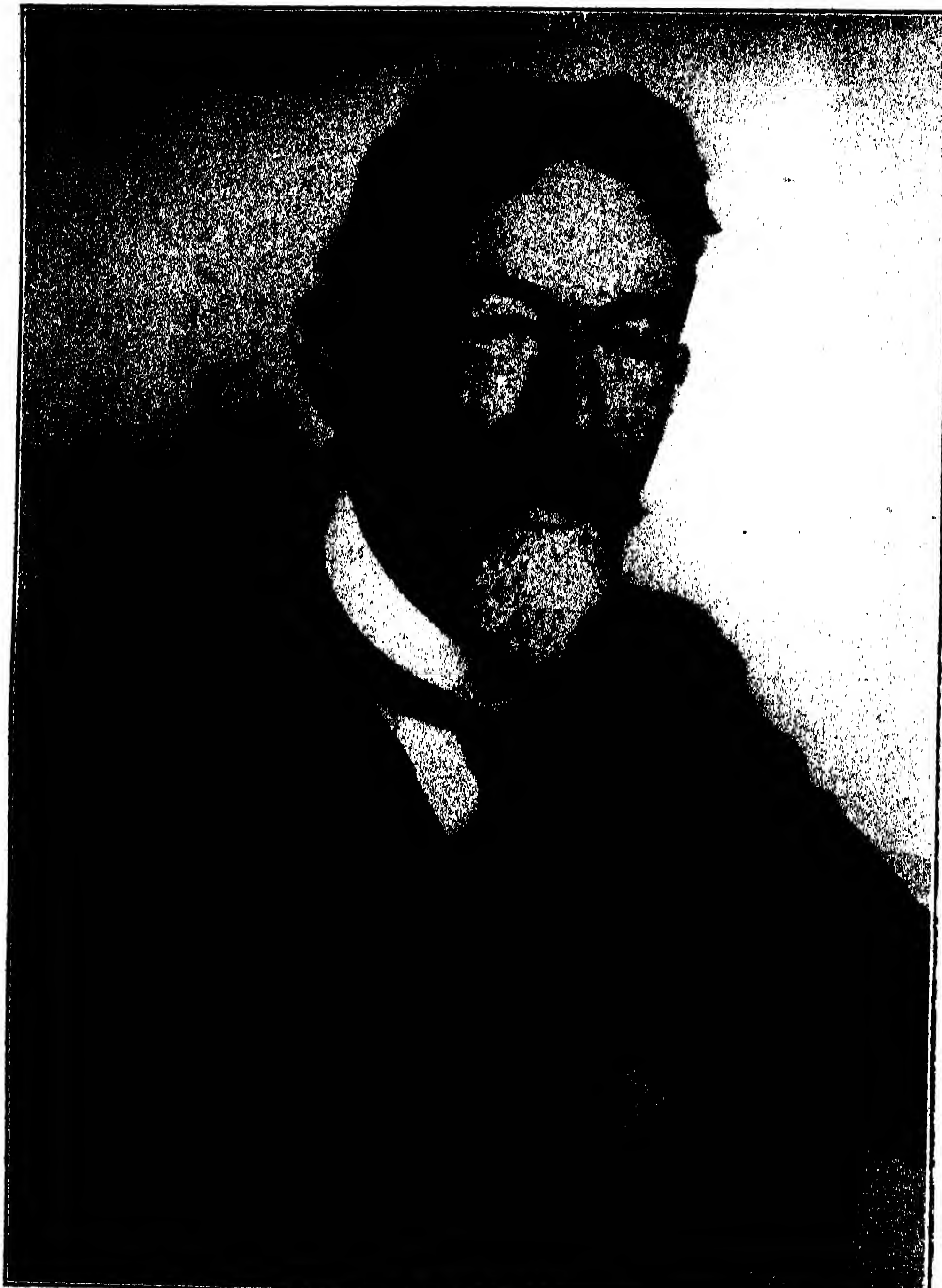


PROFESSOR JAMES FRANCK
UNIVERSITY OF GÖTTINGEN, WHO HAS RECEIVED A NOBEL PRIZE IN PHYSICS.



PROFESSOR GUSTAV HERTZ

UNIVERSITY OF HALLE, WHO HAS RECEIVED A NOBEL PRIZE IN PHYSICS.



PROFESSOR RICHARD ZSIGMONDY
UNIVERSITY OF GÖTTINGEN, WHO HAS RECEIVED A NOBEL PRIZE IN CHEMISTRY.

PROFESSOR THEODOR SVEDBERG
UNIVERSITY OF UPPSALA, WHO HAS RECEIVED A NOBEL PRIZE IN CHEMISTRY.

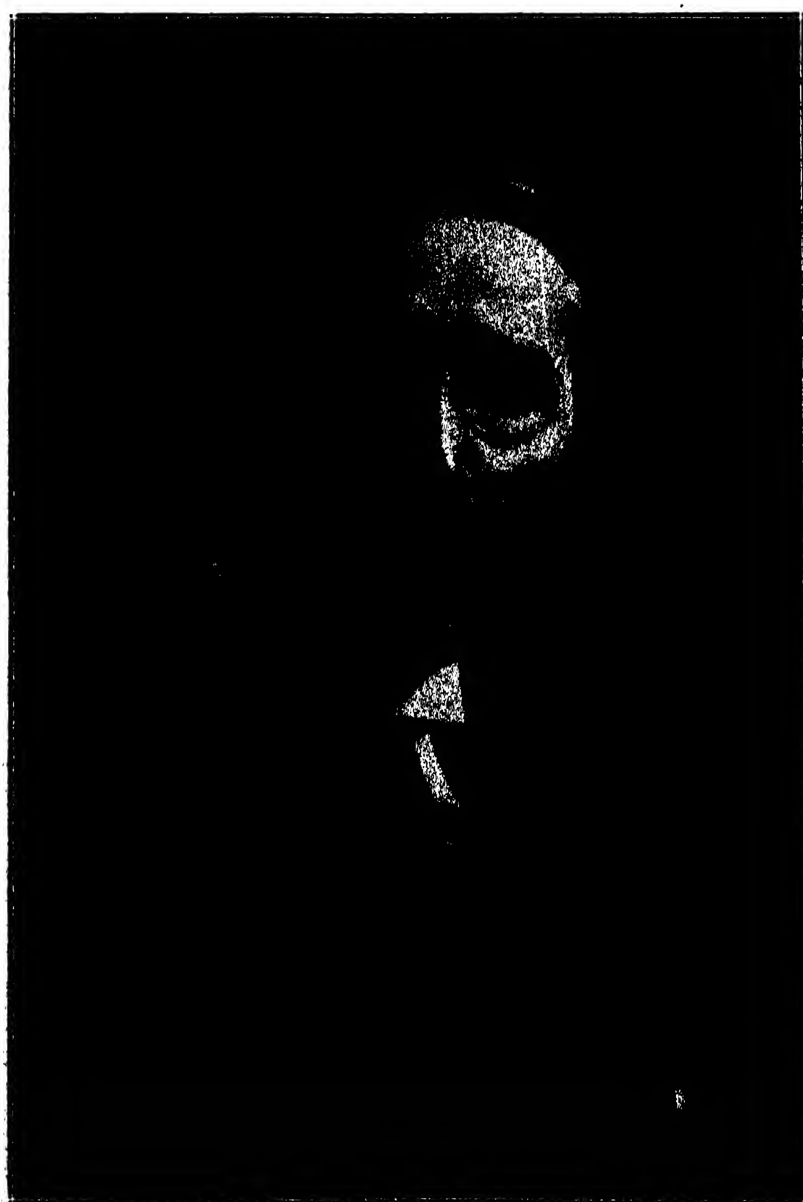
same way scientists have assumed that molecules would act in accordance with the kinetic theory of gases. He has been more recently concerned in studies to show the effect of light on chemical reactions.

MAKING AND UNMAKING MATTER

THE greatest scientific achievement of the nineteenth century, in the opinion of those who lived in that century, was the formulation of two fundamental physical laws of the universe, the conservation of mass and the conservation of energy. According to these matter and energy were immutable in amount and neither could ever be created or destroyed in the minutest measure.

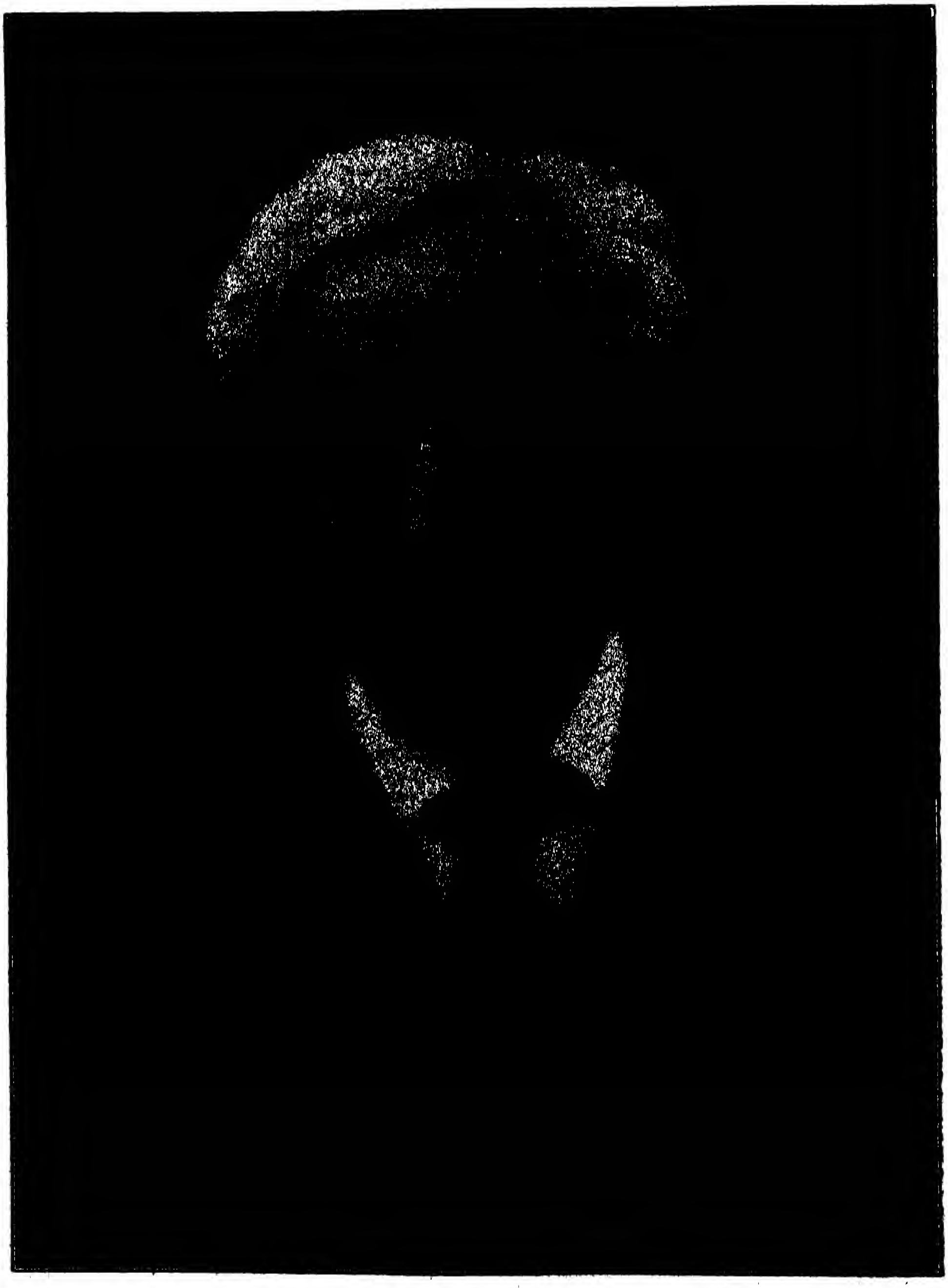
But the twentieth is an unsettling century. Such mental revolutionists as Einstein, Planck and Bohr have opened our eyes and widened our outlook. We can not be so cocksure about many ideas as were the simple-minded scientists of the former century. Some of the generalizations which seemed to them absolute and universal principles of nature appear to the more critical eyesight of the present generation to be disguised definitions; similar, as Eddington puts it, to the great law to which there is no exception, that there are three feet in every yard.

For instance, the law of the conservation of energy. We see a lump of burning coal giving off energy at a great rate as radiant heat and light. Where did that energy come from? Where was it when the lump was cold, if no energy can be created in the course of combustion? The reply of the nineteenth century chemist was clear and decided. The energy was there all the time in exactly the same amount, although its presence could not be demonstrated because it was in the form of "potential energy." Obviously this was unanswerable as an argument, although not very enlightening as an explanation. We are now-a-days disposed to suspect that this "potential energy" was put into the coal by logic rather than by geology, and that if it exists in nature at all it is in the nature of the human mind. The twin laws of conservation of matter and energy are as useful as ever, for they still serve to clarify our conceptions and to guide our experimentation. No experiment has ever been able to detect the slightest flaw in them, and it may never be possible to devise tests so delicate as to disclose any discrepancy. Yet neither law is now regarded as absolute in itself and it seems that we shall have to substitute a general law which will include the two and allow for the transformation of matter into energy and *vice versa.* Einstein has worked out the formula for the equivalence of matter and energy, so we can now calculate how much heat will be produced if a certain mass of matter is annihilated. This idea has been welcomed by the astronomers who have long been hard put to it to devise means of keeping up the furnace fires of the sun as long as mankind would like to live. They have now figured out by Einstein's formula that the sun is losing weight through the destruction of its material and the emission of immaterial energy at the rate of four million tons a second. But even though wasting away at this appalling rate the sun can hold out for ten million million years. This gives a welcome extension of time for the life of our world and permits us to hope that we may get our social system perfected before we all become Eskimos.



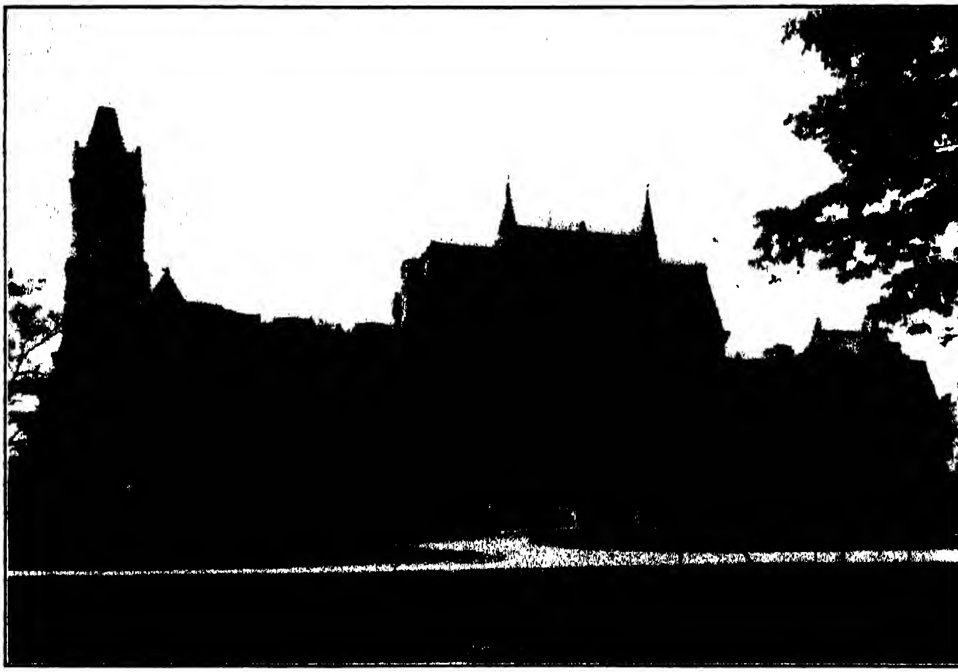
DR. MICHAEL I. PUPIN

PROFESSOR OF ELECTROMECHANICS AT COLUMBIA UNIVERSITY, RETIRING PRESIDENT OF THE AMERICAN ASSOCIATION, WHO WILL GIVE THE ANNUAL ADDRESS ON "FIFTY YEARS' PROGRESS IN ELECTRICAL COMMUNICATION."



DR. LIBERTY HYDE BAILEY

FORMERLY DIRECTOR OF THE NEW YORK STATE COLLEGE OF AGRICULTURE, CORNELL UNIVERSITY, PRESIDENT OF THE ASSOCIATION.



COLLEGE HALL

CONTAINING THE ADMINISTRATIVE OFFICES AND OFFICES AND CLASSROOMS OF THE COLLEGE, THE SCHOOL OF EDUCATION AND THE GRADUATE SCHOOL.

THE PHILADELPHIA MEETING OF THE AMERICAN ASSOCIATION AND ASSOCIATED SOCIETIES

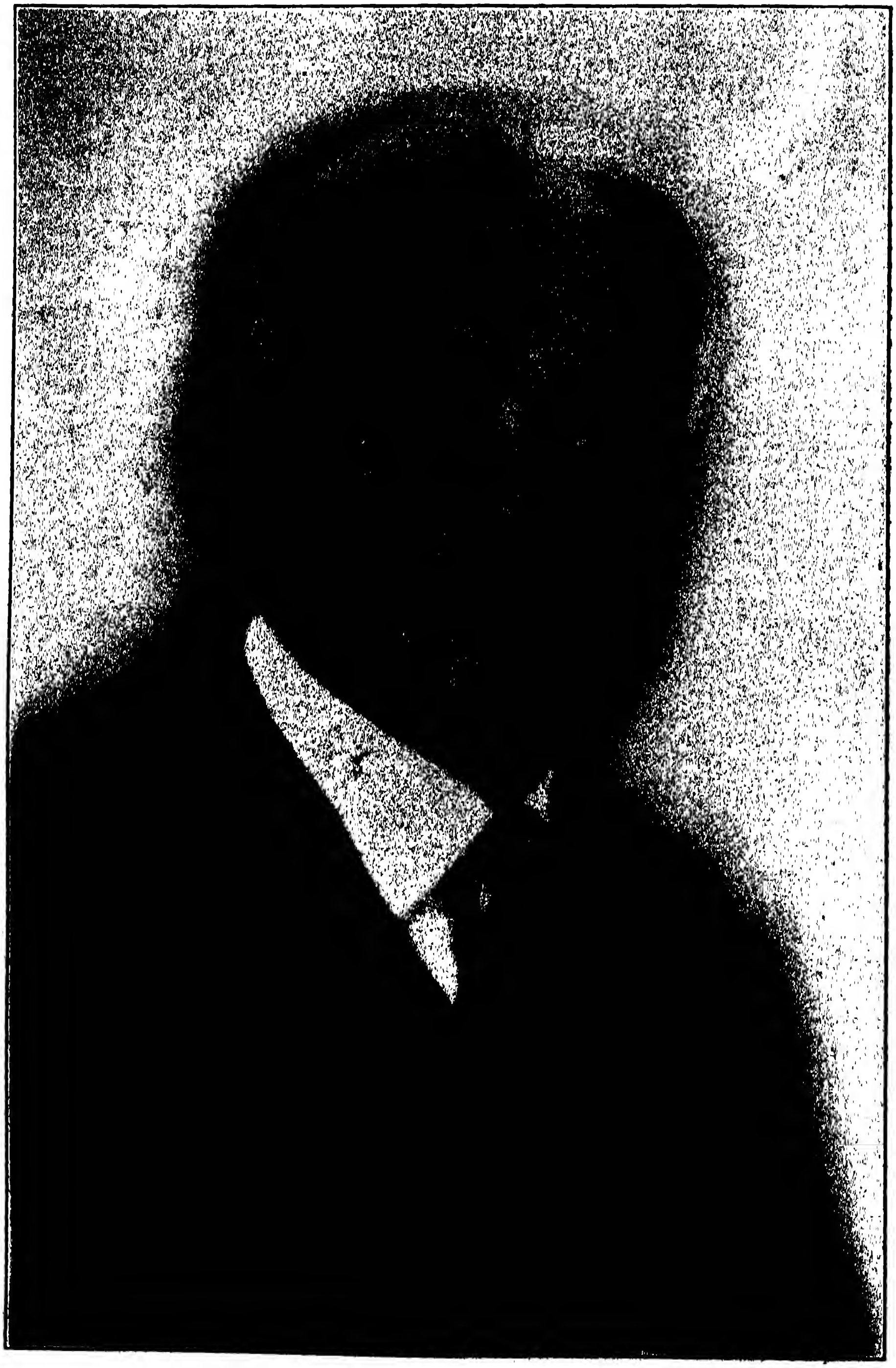
BY DR. BURTON E. LIVINGSTON

Permanent Secretary of the American Association

THIS year's convention of the American Association for the Advancement of Science and a large group of scientific societies that meets with it will occur in Philadelphia, from Monday, December 27, to Saturday, January 1. This will be the fifth time the association has met in Philadelphia. It was founded in that city in 1848. Twelve years have passed since the fourth Philadelphia meeting.

The president for this year's convention is Dr. L. H. Bailey, whose scientific work is well known to botanists and horticulturists. He was for many years dean and director of the New York State College of Agriculture at Cornell University. The rapid and permanent development of that college was due largely to his broad foresight. Dr. Bailey is this year president also of the Botanical Society of America. He was president of the International Congress of Plant Sciences, held at Cornell University last August. He is at present engaged especially in a special study of the palms. He has written much on rural economics and in kindred fields.

The retiring president of the association is Dr. Michael I. Pupin, professor of electromechanics in Columbia University, known far beyond the limits of his scientific field, especially on account of his autobiography, "From Immigrant to Inventor," for which he received the



DR. BURTON E. LIVINGSTON
PROFESSOR OF PLANT PHYSIOLOGY IN THE JOHNS HOPKINS UNIVERSITY, PERMANENT SECRETARY OF THE AMERICAN ASSOCIATION.

Pulitzer Prize. His discoveries and inventions are everywhere in use in cable telephones and radio apparatus. The retiring president of the association always gives the principal address at the opening session of the annual meeting, on the evening of the first day. Dr. Pupin's address will be on "Fifty Years' Progress in Electrical Communication."

The meeting at Philadelphia is to be open to all who wish to attend. Besides the fifteen sections of the American Association, each representing one of the branches of science, there will be meetings of thirty-nine independent scientific organizations in many special fields, with addresses and papers bearing on almost every topic of scientific research. Every evening and every afternoon there will be general sessions devoted to papers and addresses of a general nature, by eminent men of science. Among these addresses will be one on "Cambridge University," with illustrations, by Professor George H. F. Nuttall, director of the Molteno Institution for Research in Parasitology, Cambridge University, Cambridge, England. Another will be on "Geographic Conditions of Ancient Greek Culture," by Dr. J. L. Myers, general secretary of the British Association for the Advancement of Science. Mr. Herbert Hoover will give the annual Sigma Xi lecture at a joint session of the Association and the Society of Sigma Xi, on Tuesday evening, December 28. Mr. Hoover's address is entitled "The Nation and Science."

A new feature of the work of the association in connection with the annual meetings is to be inaugurated this year at Philadelphia; namely, an attempt to bring some of the atmosphere of science and of the meeting to the youth of the city, by means of non-technical lectures and demonstrations on science subjects. Four evening lectures will be given in one of the high-school buildings and tickets are to be issued beforehand to the high-school students.

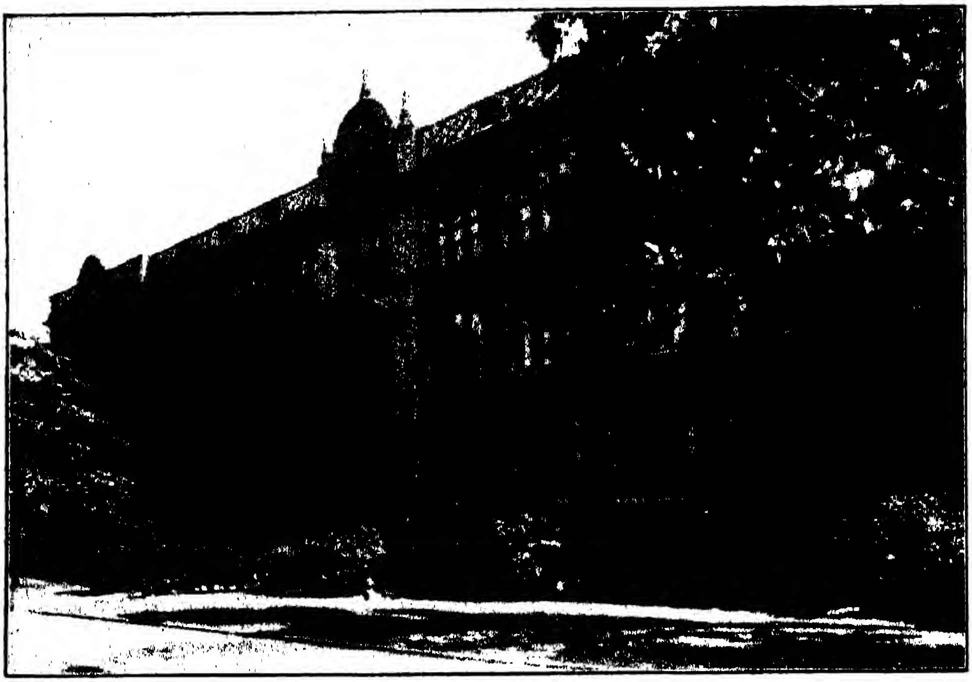
The University of Pennsylvania, the Franklin Institute, the American Philosophical Society and the Drexel Institute are very generously throwing their rooms open for the use of the convention. Most of the sessions will be held in the buildings of the university.

The annual science exhibition will this year be larger and more comprehensive than any earlier one. It will be housed in the gymnasium of the University of Pennsylvania. Many commercial firms will exhibit their apparatus, products and books, and there will be invited exhibits from individual scientists and research laboratories. Besides the general exhibition, many of the societies meeting with the association will hold smaller and more restricted exhibitions, showing recent progress in their respective fields. The general exhibition will be the social center of the meeting. Tea will be served there every afternoon and there will be special entertainments on some of the evenings, including one on New Year's Eve.

Those who attend the Philadelphia convention will have the advantage of reduced railway rates, on the certificate plan. When purchasing tickets to Philadelphia, each purchaser should secure a certificate for the meeting of the American Association for the Advancement of Science and Associated Societies. After validation at the meeting, the certificate will entitle the holder to a half-fare rate for the return trip.

The general program of the meeting will be available on Monday, December 27, and throughout the week, for all who register. Members of the association who do not attend the meeting may secure copies of the program by addressing the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C. The program will be a book of about 250 pages.

The fourth annual American Association Prize, of one thousand dollars, will be awarded at Philadelphia, to the au-



THE ZOOLOGICAL LABORATORIES

IN WHICH MANY OF THE SECTIONS DEVOTED TO THE BIOLOGICAL SCIENCES WILL HOLD MEETINGS.

thor of a notable contribution to the advancement of science presented at the meeting. The award of the annual prize has become an important feature of the meetings of the association. These prizes are made possible through the generosity of a member who wishes his name withheld.

Science Service and other organizations for the distribution of science news will be represented at the Philadelphia convention, as well as many daily newspapers. Preparations have been made for excellent news service, and the daily press throughout the country will be well supplied with material for publication. The newspapers will carry to their readers many interesting and well-written accounts of the many features of the meeting and of the scientific discoveries reported at the numerous sessions.

During the week of the convention those in attendance will receive mail and telegrams addressed to them in the care of the American Association, Registration Office, Weightman Hall, the University of Pennsylvania, Philadelphia, Pa.

Preliminary announcements of the Philadelphia meeting and other information about the American Association have appeared in recent issues of *Science*, especially in the issue for December 3rd. Copies of the special issue may be secured from the office of the permanent secretary, who also supplies a booklet on the organization and work of the association. All who are interested in any way in the advancement of knowledge are invited to membership. Although the majority of the members are of the United States and Canada yet the field of the American Association is not limited to those two countries and it has members in all parts of the world.

The photograph of Dr. Friedrich von Müller which was reproduced in the December number of THE SCIENTIFIC MONTHLY was loaned to us by Dr. Victor Robinson, editor of *Medical Life*.

THE SCIENTIFIC MONTHLY

FEBRUARY, 1927

CARL AKELEY AND HIS WORK

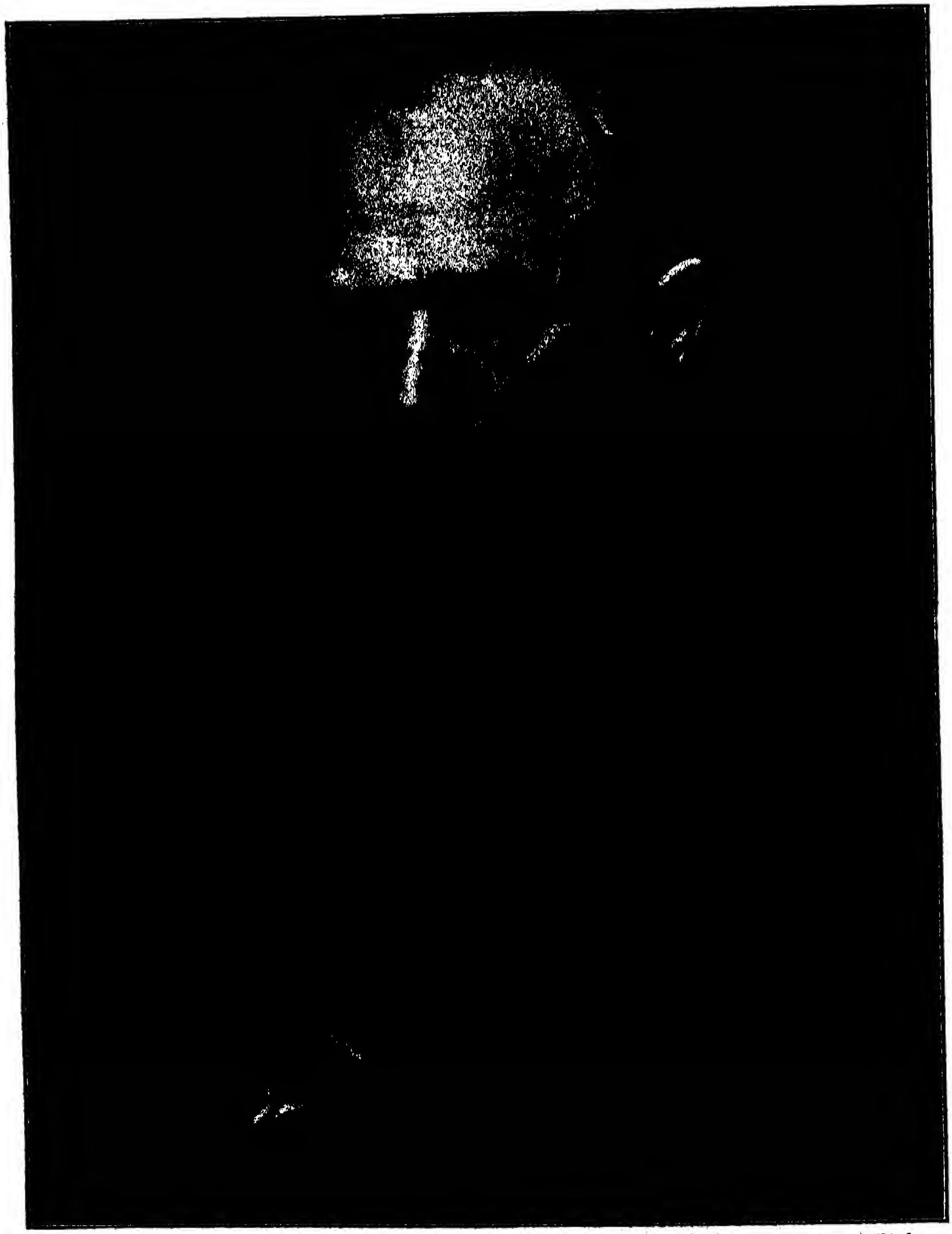
By Dr. CLYDE FISHER
AMERICAN MUSEUM OF NATURAL HISTORY

CARL AKELEY has gone, his spirit having passed on November 17, 1926, on the slopes of Mount Mikeno in the interior of "Brightest Africa," the continent he loved best. This news brought deep sorrow and a sense of great loss to hosts of devoted friends scattered over the length and breadth of the country and to the far corners of the earth. Coming in the prime of his busy life, the end seemed so untimely and so tragic. But Akeley put more into threescore years than most men do into fourscore. He remembered to live, and he did not fear the great adventure of death. "Only those are fit to live who do not fear to die; and none are fit to die who have shrunk from the joy of life and the duty of life," was as truly Akeley's philosophy as it was of his great friend who wrote the lines.

Born on a farm in Orleans County, New York, he says: "By all the rules of the game I should have been a farmer,

LION AND CAPE BUFFALO

BRONZE BY AKELEY SHOWING A LION PERFORMING THE AMAZING FEAT OF PULLING DOWN A CAPE BUFFALO. THIS PIECE OF SCULPTURE WILL SUPPLEMENT THE STORIES OF THE HABITAT GROUPS IN THE AFRICAN HALL.



Photograph by J. H. McKinley

CARL E. AKELEY IN SERIOUS MOOD

A FRIEND HAS SAID, "TO ME THERE WAS ALWAYS AN UNDERCURRENT OF DEEP SADNESS IN HIS FACE, HOWEVER MUCH IT LIGHTED UP WITH HIS FRIENDLY SMILES."

but for some reason or other, I was always more interested in birds and chipmunks than in crops and cattle." At about the age of thirteen he saw in the *Youth's Companion* an advertisement of a book on taxidermy which cost a dollar. Later he was able to borrow a copy from one of the older boys of the neighborhood. That book was probably a determining factor in his life. At any rate he became the world's greatest taxidermist, raising taxidermy to an art, and developing a method which is without doubt one of his greatest contributions to mankind. The many other products of his versatile brain, great though they are, seem to be only supplementary or complementary to his great art.

In order to enlarge his taxidermic book-lore, he took a few painting lessons from a lady in a village near his father's farm, for he conceived the idea of painting realistic backgrounds for his mounted birds and animals. So far as known, Akeley's early attempts in this direction were the first experiments with painted backgrounds for taxidermic groups.

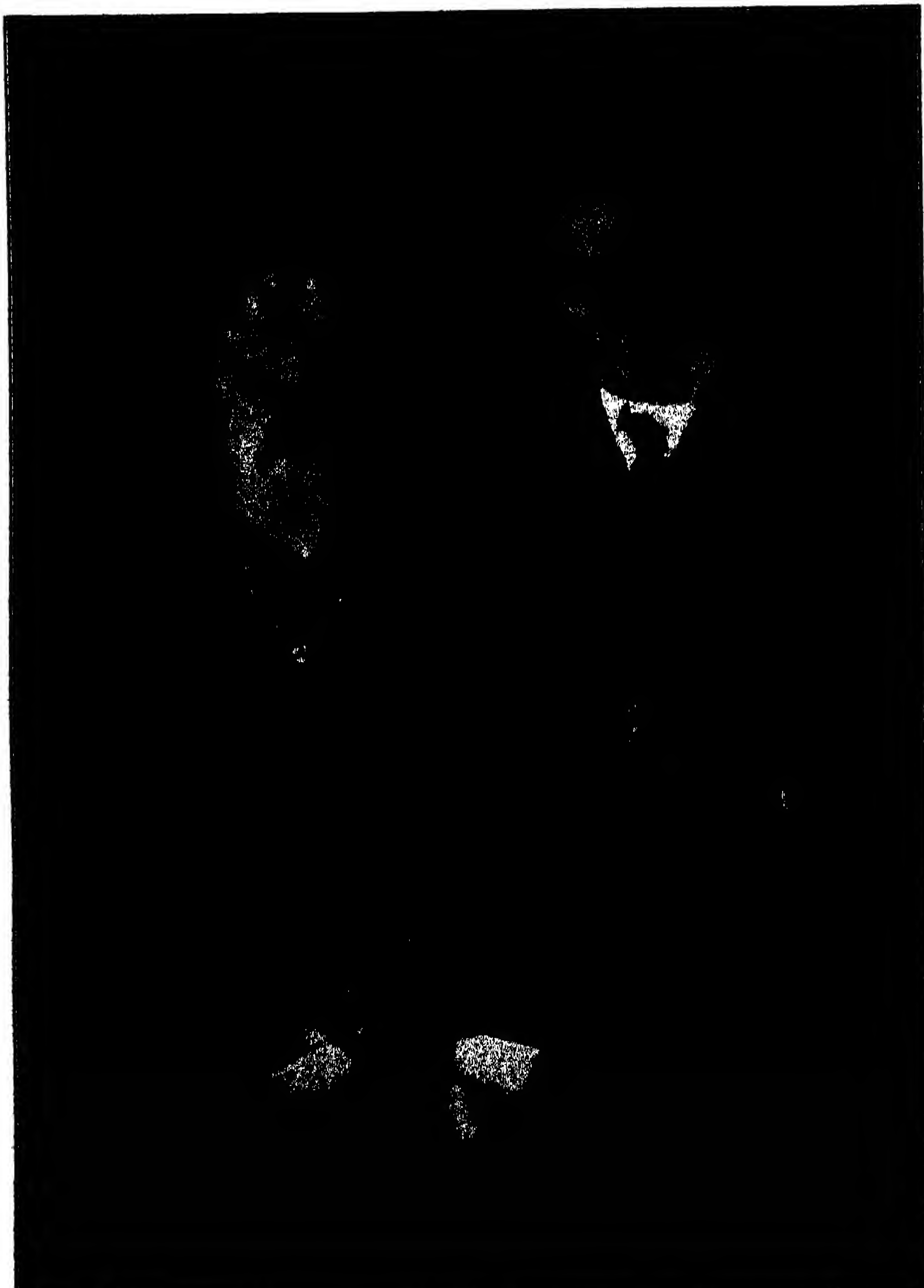
At the age of nineteen, upon the advice of a newly-made English friend, whose hobby was taxidermy, he went to Rochester, New York, and applied for work at Ward's Natural Science Establishment. During that period this was a famous institution for the collection and distribution of specimens for museums and for the training of museum curators, and further it was the headquarters of taxidermy in America.

In his autobiographical sketch (*Mentor*, January, 1926), Akeley tells us that he hardly slept a wink the night after he had decided to take his friend Bruce's advice and go to Ward's. Rising early the next morning he walked three miles to the railway station to catch the train for Rochester. Vividly he relates how he traversed most of the streets of Rochester, his courage sinking lower and lower, before he finally found the great arch, made of the jaws of a sperm whale, which marked the entrance to the establishment, and how when once on its threshold he was so overcome with awe that he had to walk a mile or so back and forth to screw up nerve to ring the professor's bell.

As a result of this visit Akeley was offered a position at the munificent salary of three dollars and fifty cents a week. He found a boarding house where he could get a room and meals for four dollars a week, and on this basis he began to learn the art of taxidermy and to run through his slender resources.

At that time the profession which Akeley had chosen as "the most satisfying and stimulating to man's soul" was neither scientific nor artistic as it was practiced at Ward's or anywhere else in the world. To mount a deer skin, for example, was a simple process. After being soaked in a "pickle-bath" containing salt and alum, and then poisoned with arsenical soap, the skin was hung upside down, the bones replaced in the legs, and the body stuffed with straw. Then to make the body thinner at any point, it was sewed through with a long needle and drawn in. The results of such upholstery can easily be imagined, and, of course, they did not satisfy Akeley's dreams, even those of his boyhood. Akeley made some drastic attempts, while at Ward's, to improve the crude methods of taxidermy, but these for the most part were not adopted, for the reason that no one would then pay for better work. As Akeley says: "Museums then were interested exclusively in the collection of scientific data. They preferred bird skins to bird groups and wired skeletons to mammal groups, and cared little for exhibitions that would appeal to the public. Professor Ward had to set a price on his work that the museums would pay."

Not being able to realize his dream of mounting animals in characteristic attitudes in the proper setting of plant life and landscape aided by painted back-



Photograph by Julius Kirschner

MR. AND MRS. CARL E. AKELEY

MRS. AKELEY HAS REMAINED IN AFRICA TO COMPLETE THE WORK BEGUN BY HER HUSBAND.

grounds, Akeley began to look to other fields. William Morton Wheeler, one of his associates at Ward's, had left and was teaching in the high school in Milwaukee. In order to help Akeley continue his academic education, Wheeler offered to tutor him if he would come to Milwaukee. Akeley accepted this kind offer and got a job at the Milwaukee Museum to pay for food and lodging while he prepared for college. He says he almost deserted taxidermy to become a professor, but the work at the museum so engrossed his attention that he definitely decided to make it his life work. He stayed eight years in Milwaukee working at his chosen vocation in the museum and in a shop of his own.

One of the directors of the Milwaukee Museum had been to Lapland and had brought back the skin of a reindeer and a Lapp sledge and harness, which he was anxious to have shown in the museum. Akeley turned this material into a group of a Lapp driving his reindeer over the snow, the first habitat group he ever built. Later he mounted a group of orang-utans in lifelike poses, using some bare branches as accessories.

The reindeer and orang-utan work encouraged Akeley to suggest a series of the fur-bearing animals of Wisconsin. The first of these to be built was the muskrat group, which still stands, after more than thirty-five years, as good as new.

From Milwaukee Akeley went to the Field Museum of Natural History in Chicago, and it was under the auspices of the latter institution, in company with Professor Daniel Giraud Eliot, curator of zoology, that he made his first expedition to Africa, starting in 1896. In this part of the world where the age of mammals is better represented in species and in individuals, especially the larger kinds, Akeley was not discouraged. On the contrary he was stimulated to attempt to bring Africa to America, not the animals alone, but the animals in their natural surroundings, a herculean task that only tremendous enthusiasm would undertake.

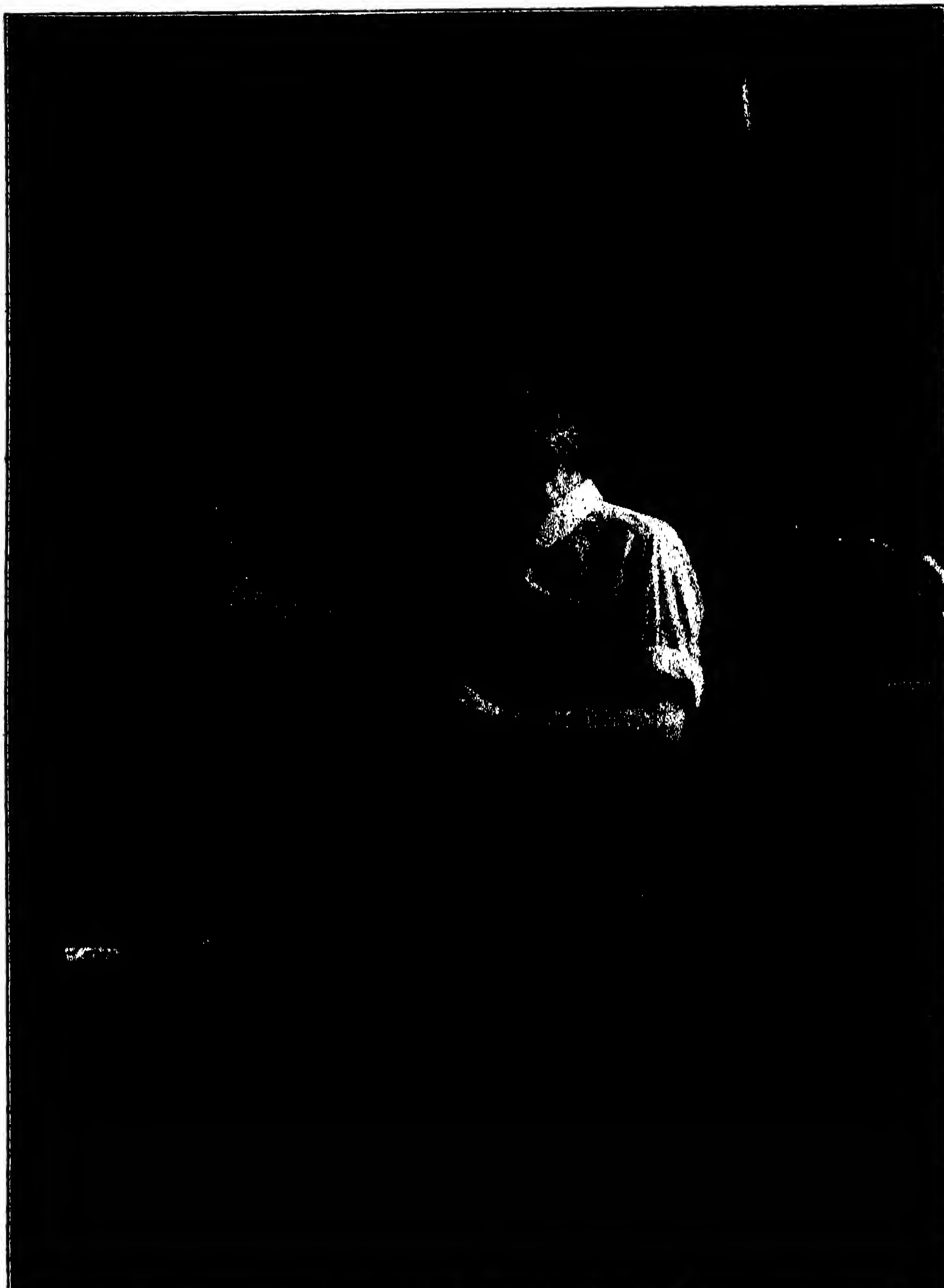
After returning from Somaliland with Dr. Eliot he worked steadily for nine years as chief of the department of taxidermy of the Field Museum, mounting the animals they had collected and at the same time perfecting his new method of taxidermy.

To do taxidermy by the Akeley method, in the ideal way—and nothing short of the ideal ever satisfied Akeley—one must know the animals in their native haunts, must be able to collect his own specimens, must know animal anatomy, and must be a sculptor, for the animal must be modeled in clay. Then he must have enough artistic sense to make his groups pleasing as well as accurate.

One of the essential features of the Akeley method of taxidermy is the manikin upon which the skin is mounted. This must be light, strong and durable. Akeley described it briefly as follows:

> The first step is the construction of a rough armature, usually of wood and wire, upon which I make a life-size clay model of the animal to be mounted. The modeling is done almost as carefully as if it were to be cast in bronze. At this stage I check the accuracy of the model by measurements made in the field, by photographs, and by "trying on" the tanned skin itself. The second step is to take a plaster mold of the clay model which can be handled in sections. Each section of the mold is then lined with glue, over which is laid a sheet of muslin. On top of the muslin are placed several layers of wire cloth and papier-mâché, each layer worked carefully into every crevice of the mold. A coat of shellac makes each layer impervious to moisture and the reinforced papier-mâché is light and durable. When the last coat of shellac is thoroughly dry, the whole thing is immersed in water, the glue melts and the sections of the manikin come out of the mold, ready to be assembled in a clean and perfect replica of the original clay model. Finally the skin is drawn over the manikin, to which it is carefully cemented, the eyes are set and other "finishing" details given attention. Then the animal is ready to take its place among the fellows that comprise the group in a scenic setting of painted background and reproduced foreground.[1]

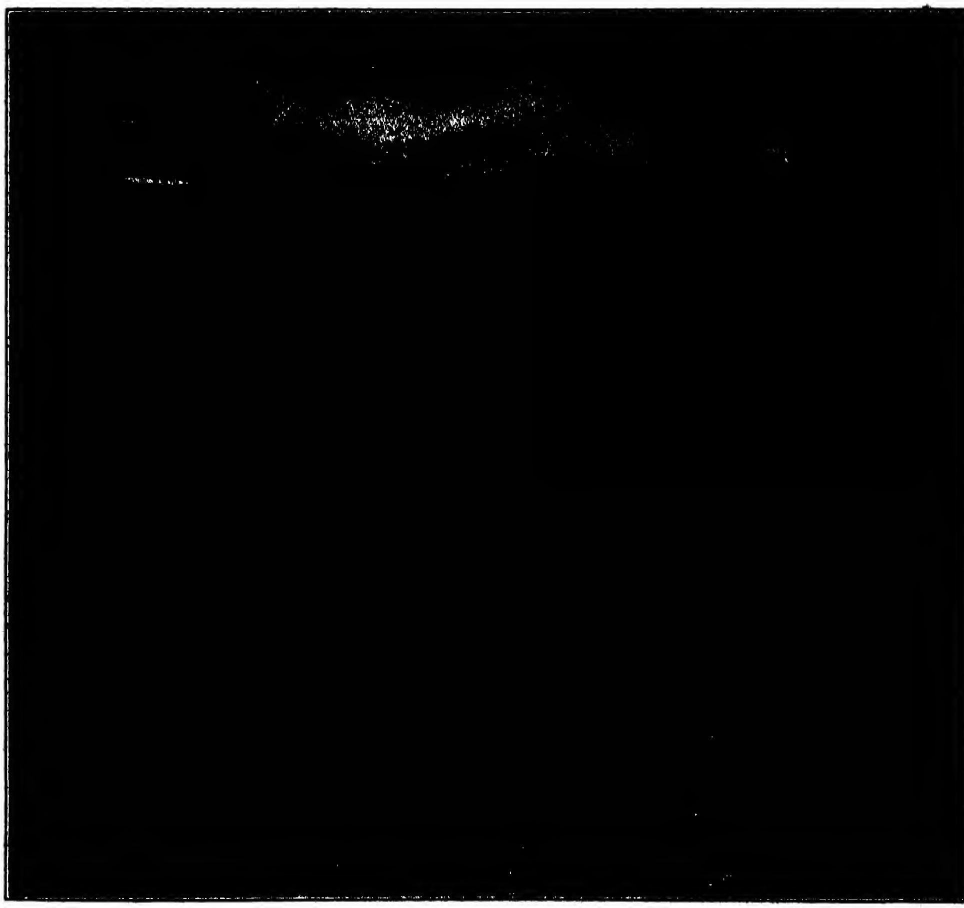
[1] *Mentor*, January, 1926.



Photograph by Clyde Fisher, September 19, 1919

CARL AKELEY IN HIS STUDIO

MODELING THE ROOSEVELT LION ON SMALL SCALE IN PREPARATION FOR THE HEROIC SCULPTURE, CONCEIVED AS A MEMORIAL FOR HIS GREAT FRIEND AND FELLOW HUNTER-NATURALIST. AKELEY FELT THAT THE LION IN ALERT REPOSE, BETTER THAN ANYTHING ELSE, SYMBOLIZED ROOSEVELT.



HABITAT GROUP OF LIONS

DAWN—THE MORNING SUN HAS STRUCK THE PEAK OF MT. KENYA BEFORE FLOODING THE PLAINS BELOW WITH THE LIGHT OF DAY.

The above description would apply to the mounting of a deer or a buffalo, but certain modifications are necessary in mounting a rhinoceros or an elephant. It should also be stated that no group is prepared without first working out all the attitudes or poses of the animals, and the general composition of the group, in a small sketch-model carefully made.

Besides the groups of African animals which Akeley prepared there is a series of noteworthy groups of American animals which has attracted attention and commanded admiration of thousands of visitors. These are the seasonal deer groups, made in Akeley's own shop and subsequently placed in the Field Museum. There are four groups in which the Virginia deer is represented in each season of the year. Here is shown the story of the shedding of antlers and the growing of new ones, the changing of the short-haired reddish coat of summer to the longer-haired gray coat of winter, the story of the young and their growth, as well as the entire cycle of the seasons in the plant life of the accessories. It took Akeley four years to complete these groups, for he had to devise, as he went along, his methods of manikin construction and of making such accessories as artificial snow, moss and leaves. These

Copyrighted. From In Brightest Africa, *by Carl E. Akeley. Courtesy of Doubleday, Page & Co.*

THE GORILLA CAMP, LOOKING TOWARD MT. MIKENO

Here the Akeley expedition camped in 1922 when in pursuit of gorillas for the American Museum. Four years later the slopes of Mt. Mikeno have become Akeley's last resting-place.

four years mark the period of greatest development in the Akeley method, and hence in the art of taxidermy.

Akeley's second expedition to Africa was in 1905, when he collected the elephants for "The Fighting Bulls," now the dominant and impressive group in the Stanley Field Hall of the Field Museum of Natural History.

In 1909 Akeley made his third expedition to Africa, and this time for the American Museum of Natural History. Among other things he collected the animals for the statuesque group of African elephants for the proposed African Hall of the American Museum. After returning home from this trip, he mounted these elephants and they have been temporarily installed in what was formerly Akeley's "elephant studio." They now stand where they were mounted, awaiting the consummation of Akeley's dream, the construction of African Hall which Akeley proposed to build as a monument to his great friend, our naturalist president, Theodore Roosevelt. In fact the cow elephant of the group was collected by Roosevelt and the calf by Kermit Roosevelt, when they were hunting with Akeley.

It was on this expedition to the slopes of Mount Kenya and to Uganda that Akeley formulated in detail his dream of African Hall. On the main floor, the dominant group will be the great elephant group which Akeley usually called "The Alarm." There will also be a family group of black rhino and a similar group of the rare square-lipped or white rhino, and flanking these, the three large bronzes of the Nandi lion-spearmen. These will endure indefinitely without the protection of glass cases. All have been finished and are ready to be installed in African Hall as soon as it has been built. Except for the bronze figures "there will be nothing in the central hall to detract from the majesty of the elephants and the lumbering bulk of these rhinos."

Around this central hall there will be forty wonderful modern habitat groups of animals, twenty of which will be viewed from the main floor and twenty from the balcony. The four at the corners will be much larger than the rest and each will comprise several species of animals. In all these groups the animals will be shown in their natural surroundings, with backgrounds painted by trained artists from sketches made in the field. An indoor field-trip through this hall when completed will be the next thing to touring completely the African wilds. As the great game animals are now decreasing, the blue-buck, the quagga and others having become completely extinct, it will soon be impossible to see as much in Africa even by the most thoroughgoing search. The historic value of African Hall will increase as the years pass.

Just above each of the twenty habitat groups on the main floor is to be placed a bas-relief in bronze representing the relation between an African tribe and the animal life with which it comes in contact. For example, one panel will show a Dorobo family and their hut and their hunting dogs. The man is skinning an antelope. The members of this tribe depend entirely upon the beasts they kill for food and clothing. This frieze of bas-reliefs in bronze and such sculptures as the Nandi lion-spearmen bring out the relation between human life and animal life.

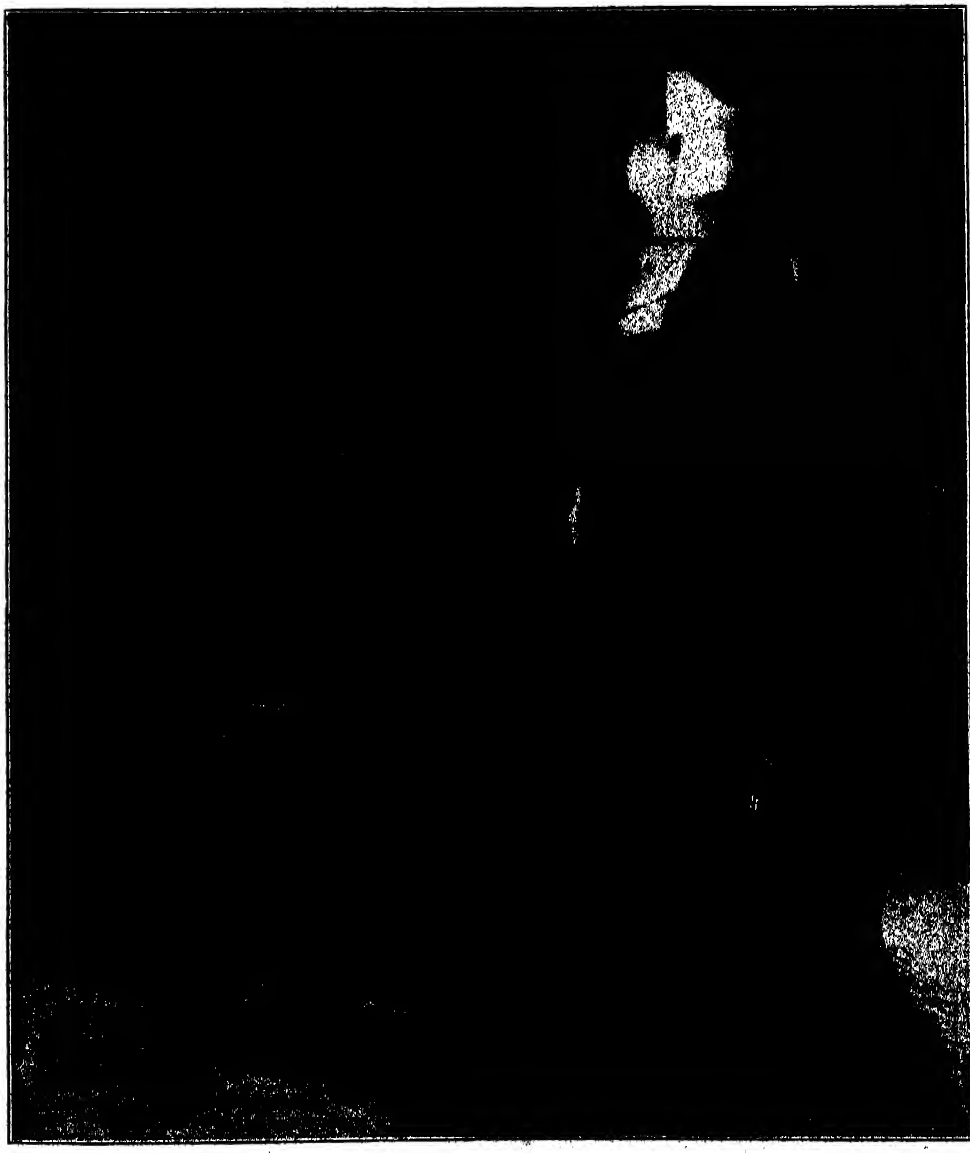
The habitat group of lions has already been finished and is ready to be moved over into African Hall when that is ready. Several other animals have been mounted and are ready to be installed with the proper accessories—for example, the gorillas.

By a one-sided skirmish with an old bull elephant, Akeley was compelled to postpone his study of the gorillas which he had planned as a part of his third expedition. In this encounter Akeley was left crushed and unconscious, and

Copyrighted by Carl E. Akeley

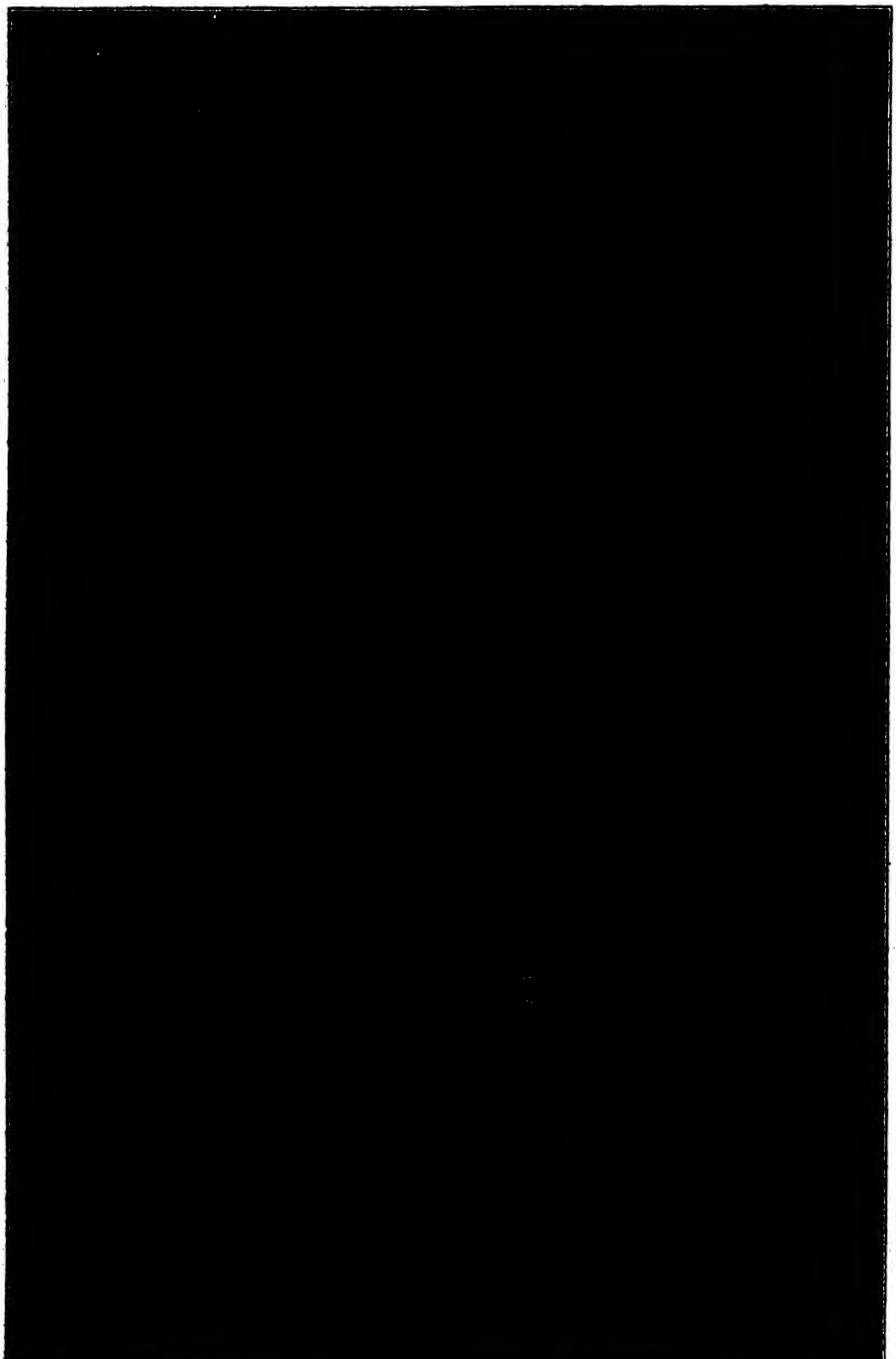
GORILLA COUNTRY FROM MT. KARISIMBI—MT. MIKENO IN BACKGROUND

THE OLD MALE GORILLA OF KARISIMBI WAS TAKEN HERE. SOME SUCH SCENE AS THIS WILL BE USED IN THE PANORAMIC BACKGROUND OF THE HABITAT GROUP OF GORILLAS IN THE AKELEY HALL.



GROUP OF GORILLAS COLLECTED AND MOUNTED BY CARL AKELEY

THE SPECIMENS ARE TEMPORARILY PLACED, LATER THEY ARE TO BE INSTALLED IN THEIR NATURAL SURROUNDINGS WITH PANORAMIC BACKGROUND. IT IS PROBABLE THAT AKELEY'S LAST WORK WAS COLLECTING THE ACCESSORIES FOR THIS HABITAT GROUP. THE CABLEGRAM STATES THAT DEATH CAME ON THE SLOPE OF MT. MIKENO, AND IT WAS THERE FOUR YEARS AGO THAT HE SHOT HIS BIGGEST GORILLA.



Photograph copyrighted by Carl E. Akeley

A HERD OF IMPALA AT THE WATER'S EDGE

Of the many species of antelope in Africa, the impala is among the most beautiful and graceful. This photograph suggested to Akeley an effective treatment of the far bank of the river which will be represented in the water group for African Hall.

several months were required for his recovery. It was not until his fourth expedition to Africa in 1921–1922, that he entered the Kivu country, the home of the gorilla. At this time he made the first motion pictures ever taken of wild gorillas in their natural surroundings. By his studies he showed that this man-like ape is hardly wild, that it is not at all the ferocious beast that it was formerly reputed to be. The gorillas already prepared for the African Hall are the only ones ever mounted by a man who has seen them free in their native haunts.

On his fifth and last expedition to Africa, on which he embarked January 30, 1926, he was joined by Mr. George Eastman and Mr. Daniel E. Pomeroy, whose generosity had made the trip possible. It was planned to collect the material for five of the large groups of African Hall. Akeley was probably collecting accessories for the gorilla group as the last bit of work he did in Africa, for he passed away, according to the cablegram, on the slopes of Mount Mikeno in the heart of the gorilla country. His intrepid and courageous wife, Mary Jobe Akeley, herself an alpinist of international reputation, has remained in Africa to supervise the completion of his work.

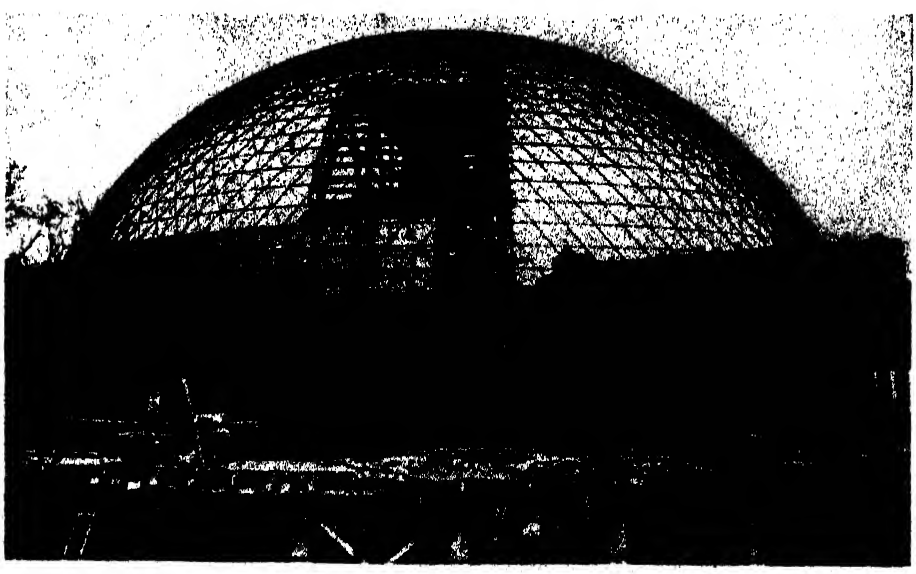
The foregoing brief account outlines Akeley's accomplishment as an explorer, as a hunter-naturalist and as a taxidermist. As has been indicated, to be a taxidermist by the Akeley method, one must be a sculptor, and Akeley has told in small bronzes several dramatic stories of African life, besides the three large bronzes illustrating the Nandi lion-spearmen. These smaller bronzes will supplement the habitat groups of African Hall. Of these bronzes my favorite and the favorite of many of his friends is "The Wounded Comrade." In this a bull elephant, having been wounded by a hunter's gun, is being helped from the field of danger by two strong comrades.

Akeley was an unusual combination of the practical person and the artist with imagination, and these two phases of his nature always functioned together. However, several times in his life his inventive genius has sprung to the fore and he has produced some noteworthy machine. It is possible that we overemphasize the practical side of the inventor. Is it not probable that an inventor is always an artist?

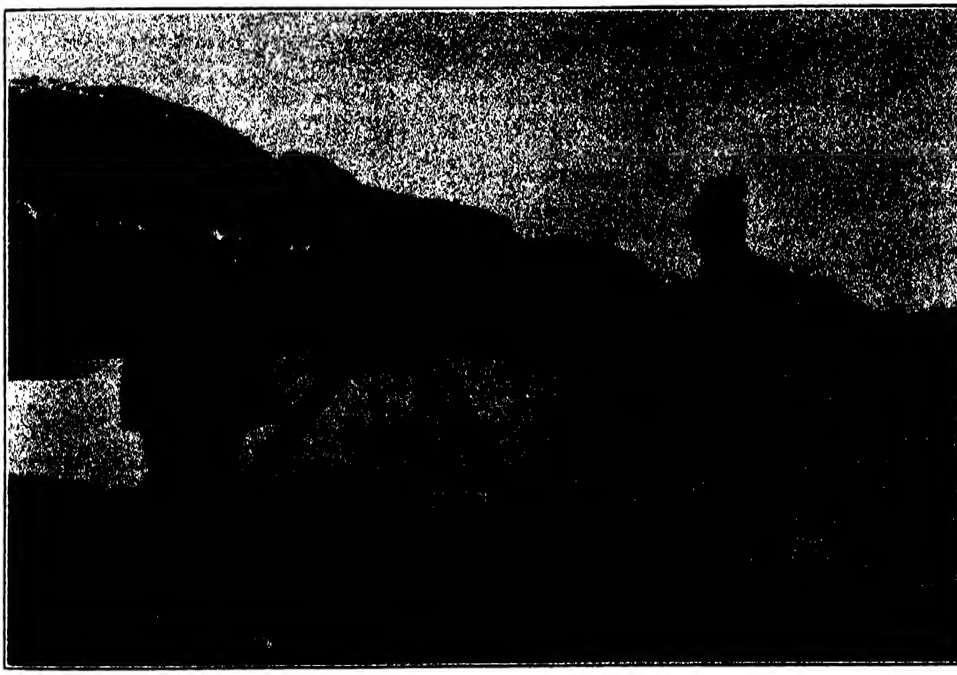
While he was a member of the staff of the Field Museum, that institution was housed in one of the buildings of the Columbian Exposition. During this time there developed a need for repairs to the stucco, and Akeley invented the cement gun to do the work. This is a modification of a compressed air spray which he devised for manikin making. By means of the cement gun, liquid cement is sprayed on in concrete construction. In this way a better quality of concrete is secured than in any other way, to say nothing of the convenience in certain cases. The Akeley cement gun was used in the construction of the Panama Canal, in lining trenches on both sides in the Great War, and for numerous other purposes throughout the world. In recognition of this invention, Akeley received the Scott Gold Medal of the Franklin Institute.

The Akeley camera came as a result of the inventor's disappointment upon finding that the conventional motion picture camera was too slow to be used in the field, especially in photographing such episodes as lion-spearing, which will not wait. From the tripod up, Akeley produced a camera far better adapted to the needs of the field naturalist than any in existence. His inventive genius may be appreciated when we realize that the Akeley camera is a distinct improvement on all other standard cameras in more than a dozen ways. It will suffice to mention two or three. It can be set up for action more quickly than any other. This was one of the main objects

AKELEY CEMENT GUN AT PANAMA CANAL
IN USE FOR THE PURPOSE OF PREVENTING SLIDES IN CULEBRA CUT.



THE AKELEY CEMENT GUN
IN USE APPLYING CONCRETE TO STEEL FRAMEWORK OF DOME FOR ZEISS PROJECTION PLANETARIUM IN JENA.



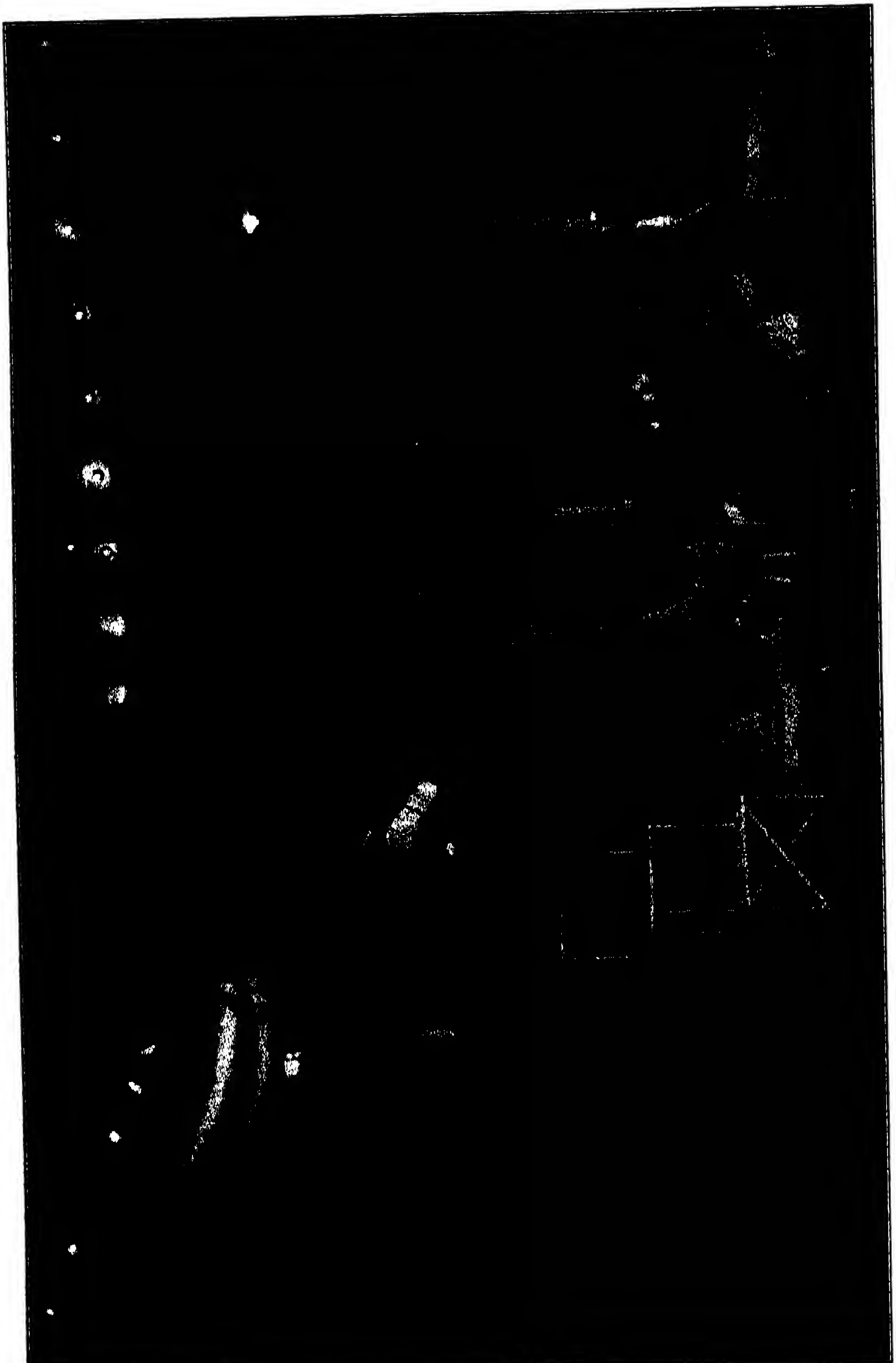
AKELEY CAMERA IN ARCTIC LAPLAND

In 1924 the writer used this camera in making a photographic record of the summertime activities of the Lapps. This is reminiscent of the first habitat group Akeley ever made, that of the Laplander driving his reindeer over the snow, a group prepared about thirty-five years ago for the Milwaukee Museum. The Akeley camera has been used in making many outstanding outdoor pictures—among those are "Nanook of the North" and "Moana," by Robert L. Flaherty; "The True North," by Captain Jack Robertson; those of William Beebe's expeditions; the bird pictures by Bengt Berg, the Swedish photo-naturalist; and the African pictures by Martin Johnson.

determined upon by the inventor, after his disappointment in trying to photograph lion-spearing in Africa with standard type of camera. It has the most efficient shutter, thereby enabling one to make photographs under more adverse light conditions. In the evening toward the close of the football game, the Akeley camera operators make good pictures after the other camera men have gone home. Most valuable to the naturalist photographer is the panoraming device, making it possible to "pan" upward, downward or diagonally, thus keeping the bird or animal in the field no matter how erratic its movements. On this account the Akeley camera was the only one to get a complete picture of the last race run by Man-o'War. The Akeley camera is not a studio camera. It was not planned for that purpose. It is an outdoor camera with outstanding advantages.

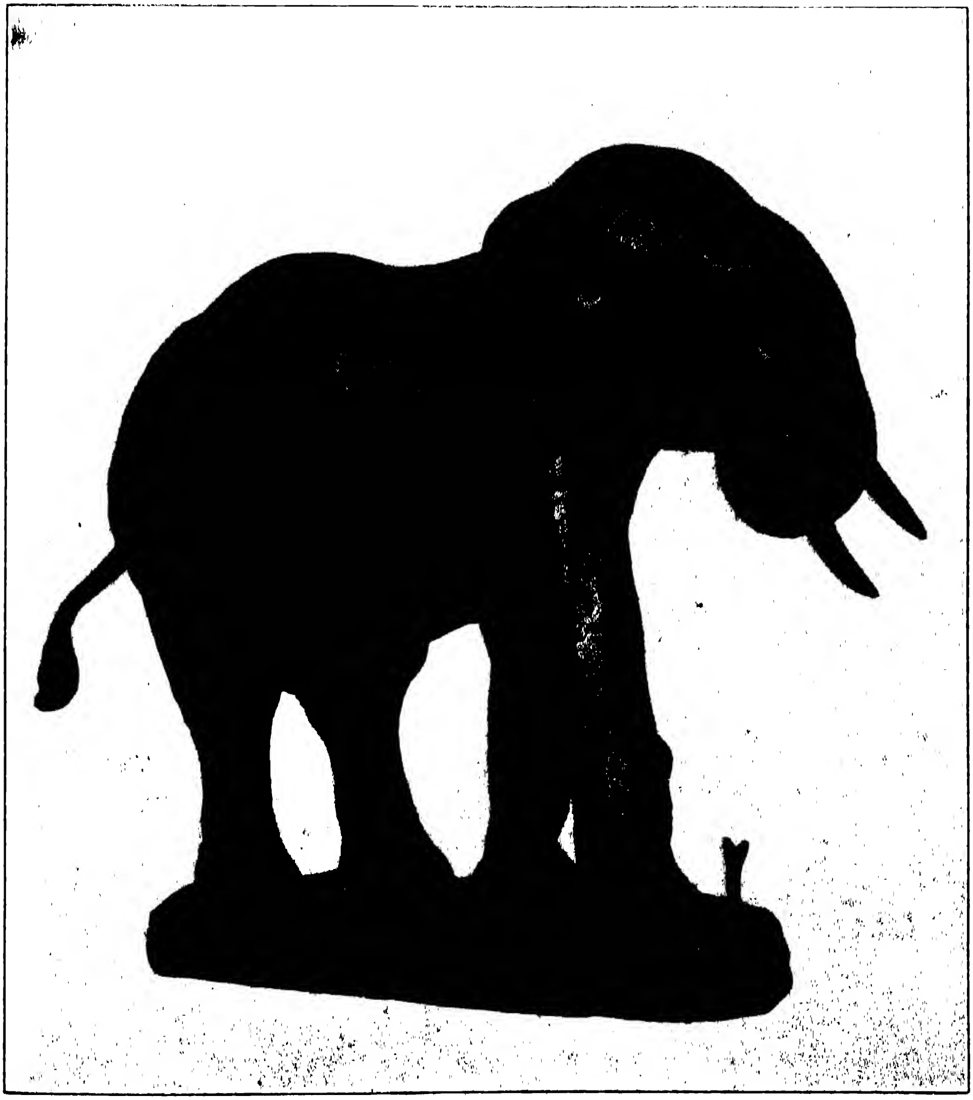
When the World War came on, Akeley was past the age to enlist, but he gave his entire time to the government in mechanical research and investigation, especially in his contribution to concrete construction and in his improvement of large searchlights.

Thirty years ago Akeley went to Africa the first time, and in his subsequent trips he came to foresee the fate of the magnificent game animals of that



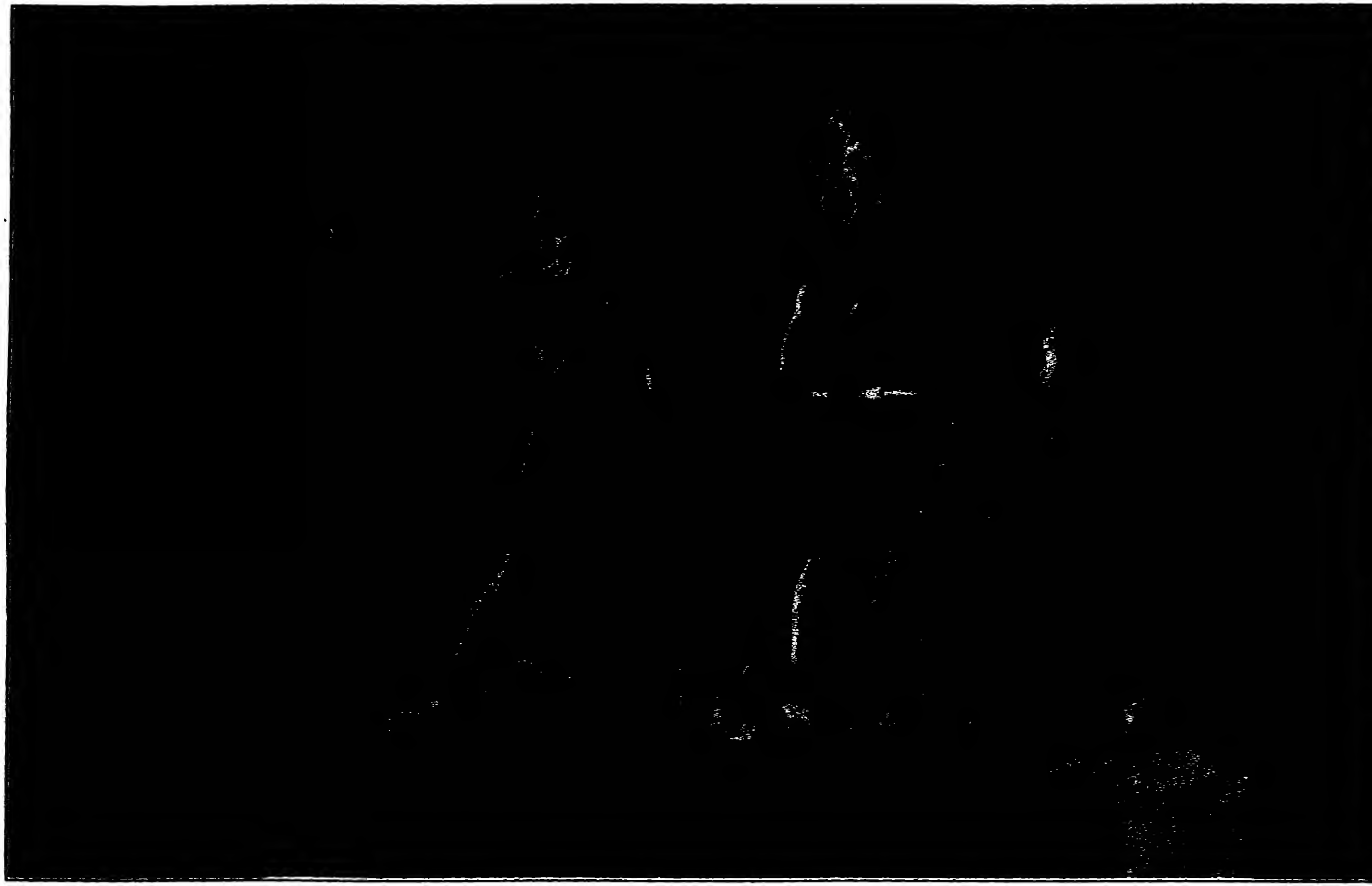
SCULPTURE IN TAXIDERMY

AKELEY MODELING THE LARGE BULL FOR THE AMERICAN MUSEUM GROUP OF AFRICAN ELEPHANTS. THE TAXIDERMIST MUST BE A SCULPTOR.



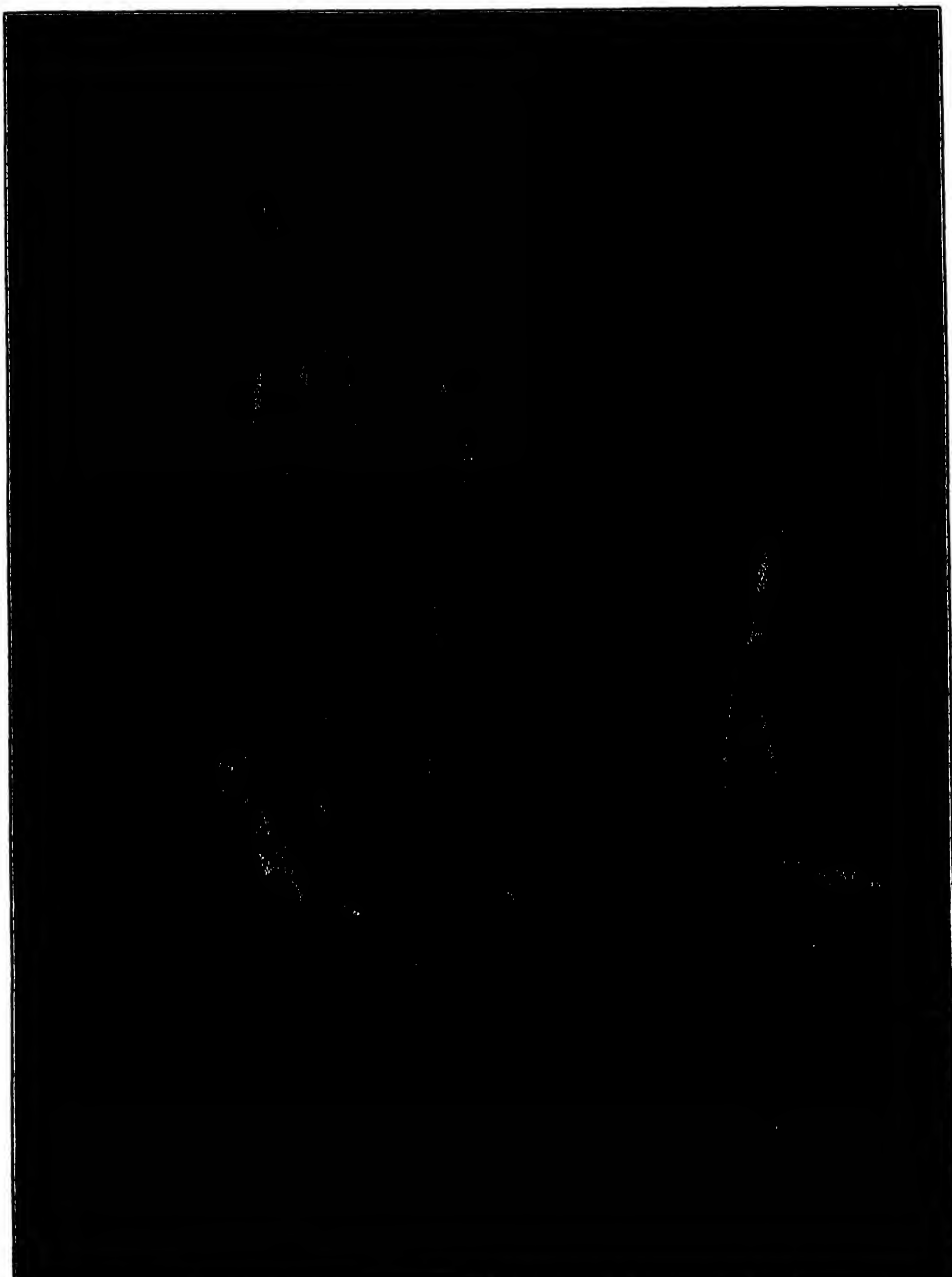
"STUNG"

SMALL BRONZE BY AKELEY REPRESENTING A YOUNG ELEPHANT TRAMPLING A POISONOUS SNAKE TO DEATH IN RETALIATION FOR A BITE ON THE TRUNK.



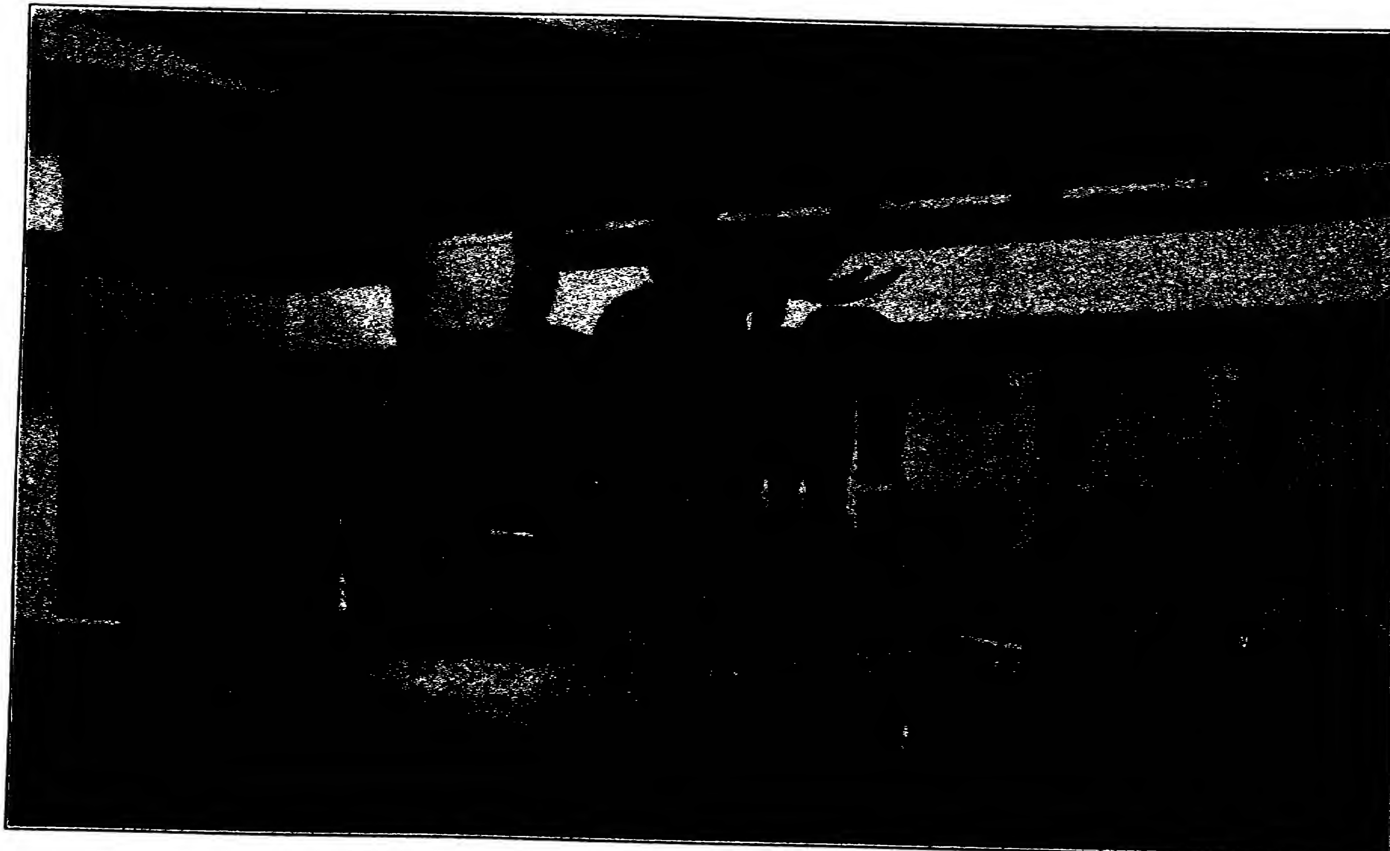
"THE NANDI SPEARMEN," BY CARL AKELEY

ONE SPEARMAN HAS THROWN AND MISSED AND NOW DRAWS HIS SWORD TO MEET THE ONCOMING LION IN MID-AIR IF NEED BE. THE SECOND IS ABOUT TO THROW HIS SPEAR. THE THIRD SPEARMAN, WHO WEARS A LION-MANE HEADDRESS, INDICATING THAT HE HAS ON A PREVIOUS OCCASION KILLED A LION IN THIS MANNER, STANDS ALERT AND READY TO REPEAT THE FEAT.



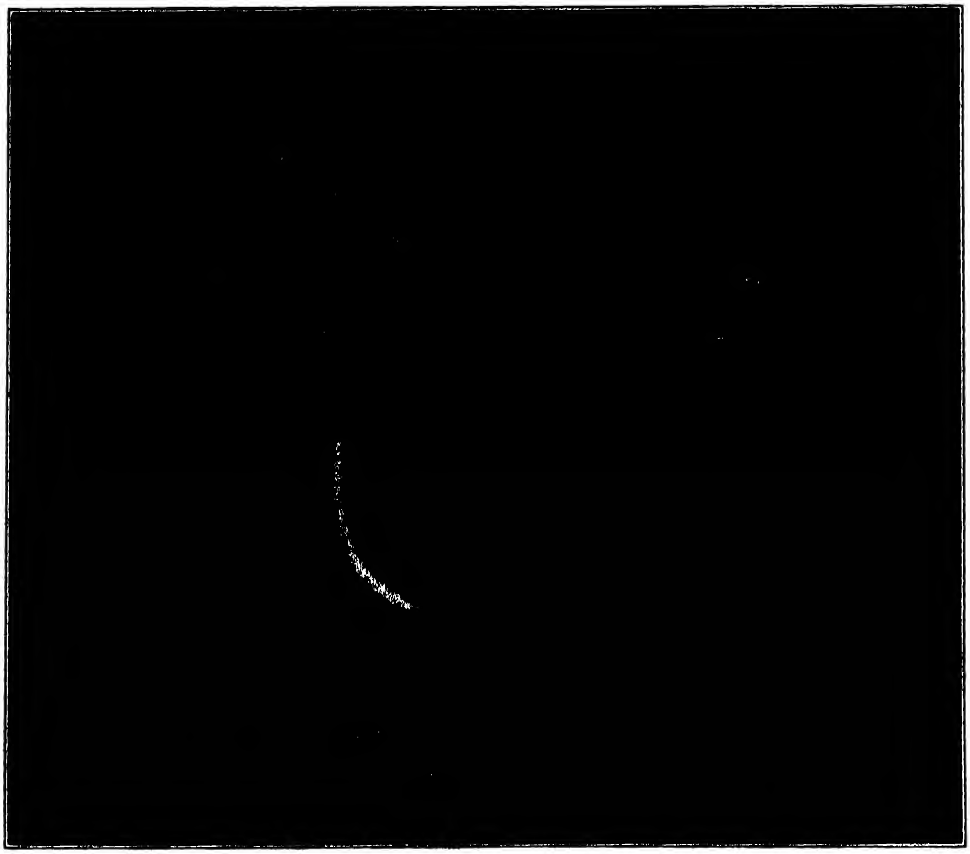
"THE REQUIEM AFTER THE LION HUNT," BY CARL AKELEY

THIS GROUP OF STATUARY, TOGETHER WITH "THE NANDI SPEARMEN" AND "THE CHARGE," WHICH IS TEMPORARILY PLACED IN WHAT WAS ONCE THE AKELEY "ELEPHANT STUDIO," WILL BE INSTALLED NEAR THE ENTRANCE OF THE AFRICAN HALL. THIS ONE SHOWS THREE NATIVE AFRICAN (NANDI) HUNTERS CHANTING A REQUIEM OVER THE BODY OF A LION.



MODEL OF AKELEY AFRICAN HALL

On the main floor the dominant group will be the great elephant group, which Akeley usually called "The Alarm." At one end will be located the black rhino family and at the other end the square-lipped or white rhino group, and flanking these will be the three large bronzes of the Nandi lion-spearmen. Around the periphery of the hall will be forty habitat groups of African animals, twenty of which will be viewed from the main floor and twenty from the balcony.



"THE WOUNDED COMRADE"

AKELEY'S FIRST BRONZE TELLS THE APPEALING STORY OF A WOUNDED BULL ELEPHANT BEING HELPED AWAY FROM THE FIELD OF DANGER BY TWO COMRADES.

continent. He realized that they were doomed to decrease and even to disappear if something drastic were not done to prevent. Akeley always was a conservationist at heart, collecting specimens only to preserve them, but he did his first great work along this line when he secured the establishment of the first National Park in Central Africa, the Parc National Albert, in the Belgian Congo. This was set apart by a royal decree of His Majesty, the King of Belgium, on March 12, 1925. It provides absolute sanctuary for all the wild life within its confines; however, the animal which interested Akeley most in his efforts to accomplish this work of conservation was the gorilla.

Akeley gives much credit to His Excellency, Baron de Cartier de Marchienne, the Belgian Ambassador to the United States, and to James Gustavus Whiteley, the Belgian consul at Baltimore, for making this park possible. We believe with John H. Finley that Akeley's memorial lives in this great Kivu sanctuary.

Now Akeley's body lies in this beautiful spot. Surrounded by the romantic charm and the great natural beauty that he loved, no more appropriate final resting place could be imagined. Moreover, it was of his own choosing. Four years

ago he said to the Bradleys, who accompanied him on that expedition, in speaking of his biggest gorilla, "I envy that chap his funeral pyre." Gazing at the fallen giant at his feet, he said, "I wish I could be buried here when I die."

In even a superficial review of Akeley's achievements, one is impressed with the unusual ability of the man. He stands out as an explorer, a sculptor, a taxidermist, an inventor, a conservationist, but more than all these, to those who knew him best, he stands out as a man, a very human man, with the characteristics that we all like, namely, straightforwardness, honesty, simplicity and genuineness. Akeley was a real man with a wonderful mind and a big heart. He loved children and he himself always succeeded in keeping a boy's heart below a man's head. One is reminded here of a quotation from Edward Simmons that Akeley liked: "'Whom the gods love die young' does not mean that they die when they are young, but that they are young when they die." This embodies something of Akeley's spirit that we like to remember.

Although Akeley could not live to see his dream of African Hall come true, fortunately he had trained, and trained well, other men who will be able to do the work in accordance with his ideals, and these men will be inspired to a great work as a memorial to their master. African Hall will be a monument to natural history, a thing of great beauty, as well as accuracy—as the realization of Akeley's fondest dream should be.

"THE CHARGE," BY CARL AKELEY

THE FIRST SPEAR HAS MISSED, AND THE LIONESS LEADS THE CHARGE WHILE HER MATE CROUCHES TO SPRING.

LAW ENFORCEMENT[1]

SHOULD THE TAX LAWS BE ENFORCED AND ENFORCEABLE?

By Professor FRED R. FAIRCHILD

YALE UNIVERSITY, RETIRING VICE-PRESIDENT AND CHAIRMAN OF THE SECTION OF SOCIAL AND ECONOMIC SCIENCES, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

TAXATION is the instrument by whose means we are induced to contribute the fund whose expenditure enables our government to perform those services which we, through our legislative representatives, have required of it. The philosophy of taxation presumes that the legislative body shall determine, first, the amount of money to be raised by taxation and, second, the machinery by which each shall be called upon to contribute his share in harmony with some general principle of equitable distribution. Taxation is thus a matter of legal enactment and administration. I invite your present consideration of what may at first blush appear to be the merely rhetorical questions: should the tax laws be enforced and enforceable?

In the old days of the absolute monarchy, the laws were not made by the people. They were imposed upon the people by the will of the king. A prevailing spirit of hostility and opposition to law was the normal condition; it was taken for granted that people generally would violate the laws if they could with impunity. Enforcement of law was accomplished only by the power of might against the will of the people. But in the theory of the modern democratic government, the laws are enacted by the people, imposed upon themselves by themselves for the common good. In the normal case it is to be assumed that the great majority are in sympathy with the laws. The officers charged with enforcement are entitled to the presumption that the people want the laws enforced and will offer, not resistance, but encouragement and cooperation. The whole problem of law enforcement takes on a different aspect from that which it wore under the absolute monarchy. To-day a law which does not have the approval and support of the great majority of the people is difficult or impossible of enforcement, simply because the old idea of enforcement by main strength against a hostile people has been abandoned and the government has come to rely upon the good will and cooperation of those to whom the law applies.

What is stated thus in general terms applies most pertinently in the field of taxation. The long and painful process by which the people exacted from their rulers the right to determine the taxes which they should pay is familiar to us all. It is to-day an axiom of government that taxes may be imposed upon the people only by the act of their own legally qualified representatives. In very truth, the people tax themselves. They determine the amount that shall be exacted by taxation and the particular tax methods by which this amount shall be obtained. The public officials charged with the duty of assessing and collecting the taxes are entitled to the assurance that what they have to do has been approved by the people themselves, and

[1] Papers presented in a symposium before Section K—Social and Economic Sciences—of the American Association for the Advancement of Science, Philadelphia, December 28, 1926.

they are entitled to presume upon the good will and cooperation of the public in carrying out this mandate.

But let no one harbor the delusion that popular cooperation may take the place of official enforcement. The tax law will not enforce itself. The taxpayers can not be called upon to shoulder the burden of enforcement. Cooperation may be counted on. Actual assistance in the administration of the tax law may be asked and obtained. The taxpayer is called upon to furnish lists of his taxable property and to render accounts of his taxable income. Information of great variety and in great detail is required. To a very considerable extent the taxpayer is asked to assess the tax against himself. But such aid is rendered only on the assumption by the taxpayer that he is doing merely what the law requires of all. He admits the necessity of taxation. He assumes that the tax system has been devised by the legislature with the intention to distribute the burden of taxation according to some reasonable principle of justice. He is willing to pay his share and even ready to aid the assessor in determining exactly what is his share under the law. All this, however, on the assumption that the taxing authorities are playing fair with him, that what they ask of him they also ask —and require—of others; in short, that the tax law is enforced.

It follows that voluntary cooperation of the taxpayer can never be turned into self-enforcement of the tax law. Failure by the duly constituted officials to enforce the law can not be long concealed. And just as soon as failure is generally known comes the end of the assumption upon which the taxpayer cooperates in enforcing the law against himself. During the American Revolution, the Continental Congress had no authority to tax the people. Instead it drew up its financial plans and apportioned the cost among the several states, asking each to contribute its fair share. The states were all involved in the war for independence and had of course every reason to give financial support to the common cause. Yet there arose at once in each state the suspicion that other states were not doing their part, and each state undertook to make its own contribution small enough so that it would run no risk of paying more in proportion than its neighbors. So the system of requisitions upon the states broke down. Efficient and even-handed enforcement is the price any government must pay for the good will and cooperation of the citizens in the administration of its laws.

It is here that our tax system has failed. Every American is subject to the general property tax of his state. There are forty-eight states and forty-eight separate tax laws, but their fundamental features are still much alike. It is required that each person's name be entered in a list and that opposite his name be a description and valuation of all his taxable property. Assessors are provided by law, charged with the duty of preparing these tax lists. The category of taxable property includes, in most states, not only real estate, but such forms of tangible personal property as household furniture, books and libraries, musical instruments, jewelry and intangible property such as notes, bonds, credits and book accounts, money on hand, deposits in banks and sometimes shares of corporation stock. To aid the assessor in the obviously difficult task of discovering and valuing all these classes of property in the possession of each owner, the law calls upon the taxpayer for cooperation, to the extent generally of rendering at least a list and description of all his taxable property. But the law never contemplates self-assessment. The official tax list is the work of the assessor. Nothing that is required of the taxpayer relieves the assessor of the duty to discover and value all taxable property of every owner.

And how do the taxing officials carry out this legal mandate? With respect to real estate the assessors do generally make a serious attempt to examine and value all taxable property, at least once in three or four or more years. As regards personal property, the practice varies. Obviously the duty imposed by law upon the assessors would require an actual visit to the home of each taxpayer and a careful inspection of all his personal belongings, in order to discover and value his taxable tangible personalty. Even more elaborate and complicated procedure would be required to assess intangible property. In a few states such measures are taken, more or less perfunctorily. But such inspections are the exception, not the rule. In general the assessor accepts the taxpayer's statement with little or no question, scrutiny or check. The taxpayer who omits important items from his list incurs little risk of detection or punishment. Even the absence of all items of personal property neither arouses suspicion nor leads to investigation by the assessor. In many a town it is taken for granted that few persons of ordinary means will list anything in the way of personal property. Declaration of items of household furniture, books, jewelry, etc., is apt to cause surprise on the part of the assessor. In many towns it is obvious that such declarations are unwelcome; they break into the regular routine of the assessor's office; they are not encouraged. May I read, as an extreme instance of this, a passage from the report of the tax commissioner of Connecticut of an official investigation of the taxation of property in Bridgeport, Connecticut:

The testimony relating to the bringing in of lists by taxpayers shows that the assessors, three in number, with from four to six clerks and assistants, work from nine o'clock A. M. until four o'clock P. M. daily during September annually receiving lists from and filling out lists for taxpayers. Few of the number so employed in 1923 are shown to have had experience or training of a character to fit them to perform such duties. The average working time per day for each person thus employed was less than six hours. In the fore part of the month four or five hundred were received daily, but later in the month nine hundred to one thousand lists were daily filed with or filled out by the assessors. The last day, September 30, 1923, lists were received between nine o'clock A. M. and noon. On that day and in a period of three hours, with a force of nine people employed, between seven hundred and eight hundred lists were filled out for the taxpayers, and approximately two hundred and fifty additional lists were received other than those so filled out. The last mentioned number were handed in by real estate men and others who may be presumed to be familiar with making out such lists. At certain times, if not all of the time, there was a general condition of congestion in the city hall, and lines of taxpayers, each waiting for his turn, were formed. On the last day mentioned there was fighting, and the police were called to suppress disorder. The line of taxpayers was formed to pass the desks of the assessors and clerks who were filling out the lists. It is the practice for an assessor or clerk who fills out a list for a taxpayer to read the list of the taxpayer's property of the year preceding and inquire whether the taxpayer has transferred any property during the year. If it appears that such transfer has been made, the memorandum of the town clerk, which is required by law to be filed with the assessors prior to September 1, showing transfers of property in the year preceding, is examined, and notation on the list so being made out is entered. The separate parcels of real estate are not described on the list as the law requires. A card system is maintained showing location of each parcel of property to be taxed, but the information on such cards relating to land and buildings is meager. After having filled out a list for a taxpayer, no opportunity is given him to see it, except when it is placed before him for his signature. The taxpayer is not asked if he has any other taxable property specifically mentioned on the form on which he lists the property. The taxpayer is not asked if he owns household furniture, jewelry, pianos, bonds or notes, or other taxable property. By this procedure each person thus engaged fills out from sixty to one hundred lists for taxpayers in a period daily of less than six hours, and on occasions during the closing days of September this number is much exceeded.[8]

While this is the account of an extreme case, the essential situation thus exemplified is quite general. It is well

[8] Sup. Rep. Tax Com. 1923–24, p. 7–8.

known. Taxpayers have ceased to respect those parts of the law whose enforcement is left to their own voluntary action. If no attempt is made to obtain the listing of household furniture, each taxpayer reasons that if others pay no taxes on such property, why should he? I have frequently heard some exceptionally conscientious taxpayer remark ruefully: "According to the town tax records I am the only person in my block who owns any taxable furniture, musical instruments, or jewelry," or "according to the tax records I appear to be the richest man in my district, though everyone knows there are a dozen men who could buy me out without turning a hair." Only the extremely quixotic will long permit himself to remain in this position.

Not so long ago I had occasion to test the assessment of jewelry and watches in the city of New Haven by an inspection of the records of the probate court. In the inventories of seventy-one estates examined the total value of jewelry and watches was $123,042. The late owners of this property in their last tax lists had reported as the value of this property (in excess of the legal exemption of $25) just $3,900. Of the seventy-one owners, thirty-two had filed no tax list whatever; of the rest, twenty-eight had listed nothing under this head; eleven had listed something less than the true value; while three had made a correct return. Of these three paragons of civic virtue, two were women and one was an insane man. The following plaintive wail from a not too ancient report of the Kentucky Tax Commission paints a fair picture of the situation in many states.

There are a few good assessors in the State—we say a "few" for the lack of a general term that expresses a lesser number.

The impression seems to be gaining ground throughout the State that we have a "single tax" system, and that personal property is exempt from taxation, and, inasmuch as real estate is compelled to bear the burden, it is the privilege of the owner and the duty of the officials to connive to list all property at a very low figure. In the matter of personal property no witness testified that the assessor claimed to have assessed it fully, or that the owners had intended to give it in at its worth. In substance, they contend that it is not given in anywhere, and excuse themselves on the ground that it is a matter of perjury or poverty, and exercise their right of choice.

The result is that after the number of lists that the assessor arbitrarily increases is added to the number that the County Board of Supervisors raise, there remains about 95 per cent. of the people in the State who fix the sum themselves upon which they are willing to pay taxes, and it is a safe assertion that 99 per cent. of that 95 per cent. are not inclined to pay a great amount.

In the absence of real enforcement of the law, other devices aimed to make the taxpayers toe the mark are futile. The taxpayer is required to take oath to his return. Result: "taxpayers oaths" becomes a bye-word. Heavy penalties are imposed for failure to list property. The penalties are as unenforced as the law itself. In short, that support and cooperation which might be counted on in behalf of a law well enforced is lost. The general property tax has become a notorious farce.

I have dwelt at some length upon the general property tax, the chief source of revenue of our states and their local subdivisions. The corresponding place in the revenue system of the federal government is occupied by the income tax. The situation here is distinctly better. Yet, after all, the difference is one of degree only. The high hopes with which we greeted this new taxing device some dozen years ago have been by now considerably dimmed. And the chief cause has been, I believe, the reliance upon self-assessment with inadequate checking. The returns of the largest taxpayers receive more or less careful examination, though generally so long after the time of filing as to lose much of their effectiveness. As to the returns of the more numerous class of small taxpayers, there is little beyond the checking necessary to determine whether the several items on

the return are in proper form and consistent among themselves. To a very considerable degree the taxpayers are left to determine, each for himself, what the amount of his tax should be, and there is increasing popular suspicion as to the accuracy and honesty of the returns. There is danger that the income tax may go the way of the property tax.

To place responsibility for this situation upon the taxpayers is idle. Harping on the deficiencies of "dishonest taxpayers" gets us nowhere. Is a man "dishonest" because he does not do, to his own hurt, what it is the business of the officers of his government to do? What should the honest taxpayer do? Take, for example, the case of bonds and similar investments. There is, let us assume, no serious attempt, or at any rate no successful attempt, by the assessors of his town to discover and assess such property. Owing to the escape of so much taxable property and the prevailing undervaluation of that which does not escape, the tax base is narrowed and, in order that the necessary revenue be raised, the tax rate must be correspondingly high. Rates of two per cent., three, four, five per cent. or even higher are common enough. Must the honest taxpayer list at its full value (he can scarcely enter it at any other value) a $1,000 four per cent. bond, when his local property tax rate is five per cent., and pay $50 a year in taxes on a bond from which he derives an income of $40 a year? Even if his town imposes the very moderate rate of two per cent., his tax would equal half the income from the property. Certainly this result is not in harmony with the spirit of the tax law.

Shall the honest taxpayer declare at its full value all his taxable household furniture, clothing, jewelry and other personal effects, when he knows that the great bulk of all such property of other owners is untaxed? Must he insist on the assessment of his real estate at its full value, when he knows that others put theirs in at half or a third or a quarter of its value? Is he a "perjurer" because he and all the other taxpayers in his state take oath each year to tax lists which in ninety-nine cases out of a hundred are false? Is he a crook because he does what every one else does, what the taxing officials permit or even encourage, and what he must do or be outrageously punished for his pains? As Edmund Burke said of the American colonists, you can not indict a whole people. You can not say the whole American public is dishonest, save only those few quixotic souls who, by obeying the letter of the tax law, do violence to its spirit.

No more can we lay the blame on the assessors and other taxing officials. Assessment of the property tax requires, first, the discovery of all taxable property and, second, the valuation of such property. No especial difficulty is involved in the discovery of real estate and the more bulky and visible forms of tangible personal property, such as machinery, farm animals, etc. Other forms of tangible personalty, such as household furniture, books, musical instruments, etc., present serious difficulties. Nothing short of a house-to-house search would suffice, and such procedure is most unwelcome to the taxpayer and naturally repugnant to the assessor. In the case of the more valuable forms, such as jewelry, the most thorough search would often fail to discover the taxable property. If regular house-to-house search were the rule, as it is not, much of the most valuable personal property could be readily concealed or spirited away over tax day. When we come to intangible personal property, concealment is so easy that anything like general discovery, except with the aid of the taxpayer himself, is quite out of the question.

If discovery of taxable property is a difficult matter, the process of valuation is infinitely more so. Our state tax laws pretty generally agree, I believe, upon

the meaning of value for tax purposes. They have in view the actual market value—what the property would sell for—and are thus in agreement with the concept of value as set up in the science of economics. Now, except at the very moment of sale, the determination of what a piece of property would sell for—that is, its value—is a matter of judgment or appraisal. Tax assessment is nothing other than the discovery and appraisal of taxable property.

Now appraisals, in business and practical affairs, are common enough, and every one must have some notion of the process and the conditions requisite to accurate appraisal. It will be recognized that appraisal is the work of experts and specialists, that the man capable of a trustworthy appraisal of rural real estate might cut a sorry figure if called upon to appraise the machinery and equipment of a watch factory or the inventory of a dry goods store. It will be recognized that real appraisal involves time and expense and will generally require the assistance of the owner of the property. This is what appraisal means to the business man, the banker, the insurance company, the investor. And I submit that nothing less will suffice for such assessment as will carry out the spirit of the general property tax and lead to a just apportionment of the tax burden.

But when we turn our attention to the actual facts of assessment, in the typical town, what do we find? An assessor or a board of appraisers, probably none of them expert appraisers, and even if so, necessarily expert in only a few lines, paid at a rate utterly inadequate to command expert knowledge or experience, with virtually no resources for employment of the necessary accounting, engineering and clerical assistance, and required by law to assess all the taxable property in the town in a period of a few weeks or months. The property which they must assess may include agricultural lands and buildings and city lots and residences, factories of every possible variety, with their machinery, equipment, raw materials, goods in process and finished products, stores with inventories of merchandise of infinite variety and complexity, corporation stocks, bonds, mortgages, book credits, patents, "good will," etc., household furniture, works of art, libraries, jewelry, musical instruments, and so on indefinitely.

Now there are cities which have splendidly organized boards of assessors, well paid, permanently employed, and with expert knowledge of values of real estate and possibly a few classes of personal property. But this represents the most favorable situation and applies only to the few exceptional cities. In the ordinary town, the assessing board is quite incompetent to perform anything approaching a real assessment of even a few of the classes of property under their jurisdiction, to say nothing of the whole list of taxable property.

Let me emphasize that this conclusion implies no disparagement of the great body of American assessors. They are generally men of ability and honesty, and they take their work seriously and do the best they can. The point is that the law imposes upon these men a task which is utterly impossible of accomplishment under the conditions. It is high time that the American public recognized this situation and prepared to face its necessary implications.

My time is limited, and I shall not try to develop at equal length the corresponding situations in the federal tax system. That the condition is similar will appear from the briefest glance at the operation of the income tax. The mere reading of the full text of this law would be enough to cause the ordinary citizen to entertain doubts of his own sanity. The officials charged with its administration have shown remarkable skill in constructing the forms and framing

the instructions for guidance of the taxpayer. Yet few taxpayers having incomes even moderately complex are able to make out their own returns without the aid of lawyers, tax experts and accountants. Students of the problem are becoming increasingly alarmed at the situation which has been created by the almost unbelievable complexities of the income tax law. I feel quite safe in asserting that the task of a real enforcement of the federal income tax in its present form—an enforcement which would command the respect of the taxpaying public and enable each taxpayer, when making out his own return, to assume with confidence that all other taxpayers were being required to render accurate returns—is beyond the powers of the present administrative staff or any other administrative machine which could possibly be set up.

And this again is said in no spirit of disparagement of the income tax personnel in the office of the commissioner of internal revenue. It is simply the statement of the inevitable conclusion that here again the law has placed upon the taxing officers a task impossible of accomplishment.

In thus laying before you my conclusion that the two principal taxes imposed respectively by our federal and our state and local governments are in their present form incapable of a real enforcement, I do not wish to be understood as implying that there is no such thing as an enforceable tax or even that all parts of our present tax system are unenforceable. Consider, for example, a method which has been devised by several of the states for the taxation of the public utility corporations. Having experienced the difficulties and uncertainties inherent in those methods of taxation which required an annual assessment either of the property or of the securities of these corporations, certain states determined to substitute a tax upon gross earnings. At once the whole situation was changed. The gross earnings of a public utility corporation are a simple matter of fact, shown without ambiguity in the books of the corporation (assuming, as is generally the case, that the books are kept in accordance with a prescribed system of accounts). No duty of self-assessment is imposed upon the taxpayer corporation, only the obligation to report from its accounts certain facts, including those required for any interstate apportionment which may be required. The taxing officials can readily check the accuracy of the report. Given the tax base, thus readily determined, the calculation of the tax is a simple problem of arithmetic; taxpayer and tax official will arrive at the same result. There may be features of the gross earnings tax which invite difference of opinion, but at any rate this tax furnishes an example of simplicity, certainty, smooth operation and real enforcement in startling contrast with the property tax and the income tax.

Thus I arrive at the answers to the questions which stand as the head of my essay. The tax laws should be enforced. Any other situation is intolerable. But the reason the tax laws are not enforced is that they are not enforceable. Let no one think that enforcement is to be obtained by giving greater powers or higher pay to the taxing officers, or by increasing the severity of the penalties for tax evasion or by starting a popular hue and cry against "dishonest taxpayers." In only one direction is the remedy to be sought. The tax laws must be made enforceable. How this is to be accomplished is another question, one which may well enlist the utmost skill of the tax students and experts and the patient constructive thought of the taxpaying public. But this question must be deferred to another occasion. It is not part of the title of my present essay.

THE IMPORTANCE OF RESEARCH IN ECONOMIC AND SOCIAL PROBLEMS

By Professor JOSEPH H. WILLITS

UNIVERSITY OF PENNSYLVANIA, VICE-PRESIDENT AND CHAIRMAN OF THE SECTION OF SOCIAL AND ECONOMIC SCIENCES, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A SECOND vice-presidential address may seem a little rough on the audience. One of the references to the program of this meeting, however, contains a saving clause which protects the audience. The statement refers quite properly to the words of Professor Fairchild and myself as "Introductory Remarks," implying that upon the conclusion of our remarks the real program will begin. This clause protects the audience and permits me to limit my remarks to those which are strictly introductory in character and which are directed at least as much to those who should support research as to this audience.

It may seem that a discussion of the importance of research in this general field may be somewhat foreign to the discussion in a program devoted to the subject of "Law Enforcement." But there is always a place in the discussion of any scientific problem for a reemphasis on the research base upon which the whole edifice must be built. For reasons which I shall elaborate this is particularly true in the fields of the economic and social sciences, where the factors in any problem are so numerous and so varied and where the practical judgments which must be made day by day in a democracy seem almost to place a premium upon superficial decision rather than complete study of all the elements. The very interest of society in the problems we are studying robs us of that leisure and opportunity for uninterrupted scholarly deliberation which encouraged if it was not directly responsible for much of the finest of the work of the older workers in the physical sciences. Refutation tends to follow more closely upon the quick publication of a little useful knowledge than it does upon the patient, obscure analysis and weighing of all the elements in any problem. Our energies tend to be pulled in the direction of speech-making and textbook writing rather than research.

We need to recognize a new "Malthusian" law in the field of economic and social problems. Whereas the "law" of Malthus posited that population tended to increase in a geometrical ratio and the means of subsistence only in an arithmetical ratio, this law would recognize that whereas our problems in the economic and social fields are increasing in a geometrical ratio, man's means of understanding and meeting them are increasing only in an arithmetical ratio.

It is a stressing of the obvious to dwell upon the rapidity with which our problems in the fields of the social sciences are increasing in number and in complexity. But the importance of the situation requires that we be willing to repeat things that should be familiar to all. We need and society needs to see our task in more fundamental terms than we have yet succeeded in doing.

Last March, David Houston, formerly secretary of the treasury and now president of the Bell Telephone Securities Corporation, gave a very remarkable address at Stanford University on the occasion of the opening of their new graduate school of business. It was an address filled with statistical material to illustrate the revolutionary change that had come over industrial and social America in the last fifty years. To repeat only a

few of the evidences of transformation in the scale of things and in the manner of doing things can not give an adequate impression of the completeness or fundamentalness of the revolution which has taken place within the lives of the older men in this room. But consider only a few of the more obvious of the changes that have taken place in the last fifty years and which constitute the inadequately appreciated revolution that has occurred in the size and nature of our business development and social life and problems in that period. If we take these few items merely as illustrations of that which is universally true we may perhaps imagine the speed with which the tasks to which scientists in this field address themselves have been growing:

> Nine billion dollars a year on automobiles—enough to extinguish the national debt in less than two years;
> Fifty million telephone conversations a day;
> Seven hundred million dollars a year on movies—as much as was spent for the federal government's prewar expenses;
> Four hundred millions on radio.

In the words of Secretary Houston:

> In 1776 we declared our independence of a political power; it begins to look as if in 1876 we declared our independence of nature, or rather, as if we declared our determination to control nature and to make her serve in a higher and higher degree our purposes.

In 1876, when the oldest of us here were still young, exports were worth \$600,000,000; they are now worth in rough figures \$5,000,000,000. The number of our savings banks deposits then totalled 2,000,000; now they total 45,-000,000 with deposits of \$23,000,000,000. Then 900,000 insurance policies; now 90,000,000 with a total of \$70,000,000,-000, fifteen billions more than the prewar wealth of France. Then we spent \$83,000,000 on education; now we spend more on education than all the rest of the world—or a total of \$2,000,000,000.[3]

[3] In these figures allowance must be made for changes in the value of the dollar.

These are illustrations only of the changes in the scale of things. This fifty-year period which brought more changes in business and social life than did the thousand years preceding is quite as much a change in the method of working and in the way of life as it is in the scale of business activities.

This revolution truly is breeding problems, economic and social, at a geometrical ratio. It is a good guess that the next fifty years will show at least a similar increase.

This revolution, born of physics and chemistry and engineering, has created the need, in fact, the dire necessity, for research in the field of economic and social problems. So rapidly have we built a business and social structure, a social and economic life, that we can only partly understand its problems. Whereas in 1876, casual study was sufficient to meet most of our needs, a problem then simple now becomes a major problem.

Consider, for example, the simplicity of the problem of locating a manufacturing plant in 1876 and then contrast that with the problem of locating even a small branch plant to-day. It is a problem which will concern the management for months at a time and entail an endless chain of figures. The important thing is that our economic and social facts and problems are to-day far beyond the range of casual study.

Science and its applications have so rapidly drawn the world together that we not only don't know what to believe, but our whole economic and social structure is subject to a series of strains such as labor difficulties, ups and downs of the business cycle, unemployment and neurotic diseases. The point that I would emphasize is that if we are to live successfully in this new environment, if stability not only of individuals, but also of all industry, is to be maintained, we must not base our judgment of economic business and social problems on

casual opinion, but on a systematic collection and study of the facts.

We apply this method to-day pretty well to physics and chemistry and engineering, but we are only on the verge of applying it in the field of economic and social problems. We don't ask, "What are the facts and what do they prove?" but instead we are governed in politics, in business and in economics by hunch, by gullibility, by propaganda, by catchwords and slogans, instead of by facts.

We are passingly well equipped to meet and to study our problems in the older fields of physics and chemistry and engineering, but the most vital need of our time is for properly constituted research agencies that will, day after day, week in and week out, and year in and year out, bring together and study and analyze the facts concerning our business, economic and social problems. Only so can we deal with facts rather than with fancies. The same method that has proved to be good business in the field of the physical sciences is not only equally applicable, but it is more applicable to the fields of economic and social life because there sentiment, prejudice and confidence that "one knows it all" is particularly likely to obtain.

In other words, we are like a country that has at great expense and great effort built up a technique of shipbuilding and has turned out marvelous ships, but has given almost no attention to the study of the laws of navigation. Research in the fields of economics and business is designed to bring more facts to the attention of the society which has to guide that ship or that business. Most of our emphasis has been in the direction of research in the development of a technique of shipbuilding, which is important and essential, but it needs to be matched by the other form of research if our industrial society is to endure.

The great French chemist, Berthelot, liked to think that a fitting motto for his beloved science was "savoir c'est pouvoir"—"to know in order to do." To the successes of chemical science we owe many of our "creature comforts." Yet in spite of the unbelievable contributions of science to our physical world, it has done little to adapt us as individuals to the new conditions with which we are surrounded. Science has built us an industrial machine, without studying how we are to run it; science has built us an industrial house without teaching us how to live in it. Within the limits where industry determines or affects the destinies of "us humans" there is immediate need for thorough-going research into the factors that affect the relations of individuals to our industrial and social environment. Such study is necessary to use adequately the material blessings which our natural resources and our knowledge of physics and chemistry have showered on us; indeed, it seems essential if we are to control our new material creations for human welfare, and not its "illfare."

I would emphasize just one more fact, and that is that more and more there is evidence appearing, especially in the field of social and economic research, that we are past the day when we can expect any very important results in attacking such problems by lone workers. The day of the old professor who goes into his laboratory with a test tube and half a dozen text-books is passing, and the possibility of his bringing out any very important contribution will not be considered very great in the future.

Secretary Hoover has summarized this situation by saying, "The day is past when we can expect any very consequential discovery or invention by the genius working alone in the garret."

An organized department is required because the problems exceed the points of view, the resources and perhaps the life of single individuals. Consequently we are finding in business establishments, as well as in universities, the setting up of organized research departments.

The success of our endeavors in the field of economic and social research will answer the question whether the necessary economic and human adjustments may be made to an industrialized society, whether there exists a foundation for the gloomy pessimism that says, "Not only is there a Malthusian law of population; there is an even more portentous Malthusian law of economic and social problems."

Do I need to state the relation of all this to law-making and law enforcement? What should a sound law be but a legally enforceable generalization of conduct or procedure which finds a sanction in science and which does not proceed too far for the public opinion of the time? What are our difficulties of enforcement but one evidence that we have had too much faith in cracker box philosophy and too little in scientific study of problems? If we view them fundamentally, do the difficulties in law making and law enforcement mean anything more than the use of the Conestoga wagon and the practice of blood letting did a century ago—an inadequate scientific basis for attack upon our problems?

LAW ENFORCEMENT THROUGH SELF-RESTRAINT

By Dr. HASTINGS H. HART

RUSSELL SAGE FOUNDATION

MUCH is said these days about law enforcement. The public press is filled with discussions of crime, law-breaking and contempt for law, prevalent not only among the open law breakers, the recognized enemies of society, but also among those who are ordinarily classed as law-abiding people.

Much is said also about crime waves. The press and the pulpit, the bar and the bench, unite in denunciation of the criminal classes and demand more rigorous treatment of the criminal and more faithful enforcement of the law. But what is a criminal, and what do we mean by law enforcement? A criminal is defined by the Standard dictionary as "A man who has committed an offense punishable by law"; and law enforcement, if it means anything, ought to mean holding violators of the law responsible for their acts and inflicting upon them the penalty provided by the statutes.

There is general condemnation for those who violate the laws against burglary, highway robbery, embezzlement, pocket picking, rape and murder; but a wide-spreading indifference to violators of the revenue laws, the Volstead Act and laws regulating gambling and traffic upon the highways.

It is difficult for the thoughtful student to recognize clearly the distinction which is wide-spread in the public mind between the acts committed by the "professional criminal" and those of the "law-abiding citizen." The professional criminal is artful in finding excuses for his unsocial course. He says: "I never had a chance; I was persecuted by the police; I was subjected to the tortures of the Third Degree; I got a raw deal from the district attorney; when I was a first offender I was forced into association with older criminals in jails who instructed me in crime and blackmailed me after I got out." One of the Younger Brothers, notorious bandits, who served twenty-five years in the Minnesota State Prison, said: "After the Civil War, when we were only boys, we were made outlaws and driven into the bush. They would not allow us to live as decent citizens." A prisoner in the Eastern Peni-

tentiary of Pennsylvania explained his presence there as follows: "You see it was about a horse. I took the horse with the understanding that if I liked him I was to buy him, but I didn't like him: so I sold him."

The reputable citizen who violates laws which are disagreeable to him makes similar excuses. The reckless speeder who inflicts wanton injury upon a foot passenger or upon the occupant of another car, says: "I had to make a train; I was late for dinner; my wife wanted to use the car; I love to ride fast." The woman of fashion who violates the customs law says: "I had to have those diamonds and I just couldn't afford to pay the duty; it was only a little piece of lace, it got overlaid in the tray of my trunk, and I forgot all about it." The violator of the gambling law says: "Everybody does it; what's the harm in a little bet on a horse race?" or, "It was only a five-cent ante, a game among gentlemen." The violator of the Volstead Act says: "These sumptuary laws are a violation of personal freedom. It is the duty of every good citizen to enter protest against them. Anyhow, that bootlegger held me up for three prices. I hope they will catch him and give him what he deserves."

We are in danger of laying too much stress upon the idea of *enforcement* and too little upon the idea of self-restraint. Force and fear are not the best governmental agencies for preserving good order in society—least of all in a democratic society; they should come last and not first. It should always be borne in mind that excessive severity tends to promote lawlessness, not to repress it. Harshness breeds resistance and undue severity may promote violence.

This principle was illustrated more than one hundred years ago when thieving was punished by hanging in England; but pickpockets were active among the crowds that were watching the execution of men or boys who had been convicted of stealing. It is being illustrated at the present time. Under the Baumes Act the judges of the New York courts are imposing sentences of thirty or forty years or life sentences for offenses which two years ago would have called for sentences of perhaps five, ten or at most twenty years. At the same time it is understood that the opportunity for parole before expiration of the sentence will be greatly restricted if not withdrawn.

Without debating the question of the ill desert of criminals who have been convicted of repeated offenses, it is already apparent that the imposition of these drastic sentences, together with the withdrawal of hope of earning a release on parole has a tendency to produce a feeling of reckless desperation which leads to the violent efforts to escape which we have recently witnessed in different parts of the country. Force and fear as measures for preserving order and protection of society have positive limitations, even in prisons.

The present prevalent idea that our prisons are being made pleasure resorts whose inmates are happier than their less fortunate neighbors outside is for the most part a plausible fiction. Isolated instances occur which may be open to the charge of pampering prisoners, such as the long-standing practice of allowing inmates of jails to carry considerable sums of money and to spend them for extra food and other luxuries, but these cases are exceptional.

The practice of providing outdoor recreation or indoor entertainments once a month or once a week is properly defended by experienced prison wardens who recognize that wholesome recreation is an essential part of normal human life and that it is much better to allow a prisoner to watch a ball game or listen to a concert once a week than to have him sit brooding in his cell night after night to cultivate a grouch and a spirit of bitterness against society.

The warden of the Sing Sing Prison has been severely criticized because moving pictures are exhibited in the prison several times a week at that institution. But the public does not understand that they are permitted not for the sake of furnishing amusement to the prisoner or because the warden considers their frequent use desirable but because he is compelled to keep a large part of his prisoners in horrible insanitary cells built a hundred years ago. These cells are three and a half feet wide, seven feet long and seven feet high. They are dark, ill-ventilated and unwholesome. They breed tuberculosis, rheumatism and pneumonia. Moving pictures are maintained in order to minimize the time which the prisoners must spend in these dreadful cells.

Rest assured that all prisoners suffer severely; the chief element of their suffering is the deprivation of their liberty and the necessity of absolute submission of their wills to the will of the prison warden. When the hope of liberty becomes remote the prisoner is likely to adopt desperate measures in order to obtain it.

Wise and experienced prison wardens learned long ago that the best prison discipline is that in which such a morale is established that the great majority of the prisoners are led to join cheerfully with the prison officers in maintaining order and in preserving the same spirit of industry, cooperation and good will which is essential to normal social life in the community at large.

It is unfortunately true that there is a certain portion of the community which can not be kept in order without the use of force and fear; and for this comparatively small contingent restrictive measures must be used, and while in progressive states like Great Britain and our own state of Massachusetts the proportion of such individuals has been greatly reduced, it is probable that we shall be compelled to maintain prisons and other restrictive agencies for generations yet to come.

We are recognizing, however, that the real purpose of criminal courts and prisons is not to get revenge upon those who have offended against the law but to protect society; and also that the protective power of forcible agencies, like prisons, is necessarily limited. Only a minor portion of the criminals of the community actually go to prison and their stay is comparatively brief. Sooner or later the great body of them return to the community and the real protection of society must come not from the severity of their treatment but from such a discipline as will tend to make them decent members of society, not because they are terrorized but because they have learned to be good citizens.

The Power of Self-Restraint

Many people believe strongly in the deterrent effect upon the community at large exercised by the practice of severity against the criminal. They believe that long sentences, increased hardships in prisons, the degradation and humiliation of convicted criminals all tend both to prevent a repetition of offenses and to prevent other people from becoming criminals.

Doubtless there is some truth in the doctrine of deterrence. The reckless speeder slows down when the traffic cop comes in sight, and the crowd of respectable citizens who throng the court room to listen to the trial of some notorious offender have a thrill of apprehension when the judge pronounces a sentence of solemn condemnation upon the convicted criminal. Ten thousand readers of the daily newspapers are reminded to some degree of the fact that the way of the transgressor is hard. But these lessons do not sink very deep nor do they greatly affect the minds of those reckless youths who are already taking lessons in criminal practice and who have become indurated by the idea that after all only a

fraction of the offenders against the law are brought to justice; and in the minds of thousands of them the idea prevails of taking a chance.

Respect for Law

Much emphasis is laid upon the small amount of crime reported in Great Britain and in Canada in comparison with that which is found in the United States. In visiting those countries one is impressed with the fact that there prevails a much greater respect for law than is found in this country. The English "bobby," armed only with his baton, commands more respect and more ready obedience than the American police officer who is known to carry an automatic pistol. Violators of the law are probably held in greater reprobation than with us, and the decisions even of the lower courts carry with them a greater weight of authority and public significance than those of the American courts.

> One hot day, walking on an offshoot from the old royal road that leads from Marly-le-Roi to Versailles, I saw some big ripe plums fallen from the trees and lying in the road. I picked up two or three of them—they were delicious! But chancing to speak of it, in the evening to a French friend, he was horrified. "Frenchmen would not dare!" he said. "Then it is not proper?" I asked, wondering. "Not in France! Had you not been an American there might have been trouble." "Though I picked up not more than three plums, and they were not in a field, but lying in the grass in the very road? In America a pedestrian would do that on a country road without hesitation." I felt rather proud of America by contrast with this closeness of France, and perhaps I showed that I did, when he retorted with a smile: "But the matter of boundary—is it also in America that a chicken is safe only if it is not in the road?" and I had to laugh with him.[2]

May we not believe that this different attitude of respect for law is due in part to the training of the youth, in these European countries, from childhood, to give heed to authority and to hold the law in reverence?

[2] From "Unvisited Places of Old Europe," p. 105, by Robert Shackleton, 1925.

It is possible to cultivate a habit of mind which holds in honor the authority of parents, teachers and public officers; or on the other hand to cultivate a heedless attitude in which resides contempt for authority and refusal to recognize the duty of deference to law. Is it not time that the American people should proceed deliberately to cultivate a different attitude and spirit among our people—especially young people—in this regard?

Fashion and Custom

Have you ever considered what dynamic power resides in public sentiment, habits and tradition to produce far-reaching results upon the whole community?

Fashion, for example, without the sanction of law or the authority of courts and police officers, exercises a tremendous sway over the entire community. Members of the male sex wear garments that are inconvenient, uncomfortable and needlessly expensive, solely at the dictation of fashion or custom. The derby hat, ugly, hot, destructive to the hair, survived for decades simply at the dictate of fashion, and suddenly disappeared from view under the same dictation. In warm weather men wear uncomfortable starched collars, double-breasted coats and unnecessary waistcoats, simply because it is the fashion, while at the same time women are wearing clothing of one fourth the weight and are vastly more comfortable. Men wear overcoats in the coldest weather, varying in length from a short peajacket to an ulster dangling to their heels, according to the dictates of fashion.

Women submitted for generations to the most uncomfortable, unsanitary and unbecoming clothing at the dictates of fashion and then in a brief time discarded these unseemly garments and assumed sweaters, short skirts, low-heeled shoes and knickerbockers, according to occasion; but they wear furs in summer

and thin silk stockings in winter at the dictate of fashion.

Men wear straw hats in summer, but on the arrival of the fifteenth of September, though the thermometer may be 95 degrees in the shade, straw hats disappear and felt hats take their place, and when a traveler returning from Florida exhibits a straw hat before the fifteenth of May he becomes an object of curiosity or ridicule.

Similar laws rule in matters of diet. Within the past few years there has been a remarkable increase in the consumption of vegetables, with a corresponding decrease in the consumption of meat; partly, it is true, from motives of economy, but largely from the effect of education by doctors and dietitians. Similar laws operate in the field of architecture. There are successions of different architectural schools. I remember when, about 1870, French roofs suddenly became fashionable and were applied to buildings of all dimensions regardless of their fitness for the given purpose. Many of these buildings are still standing and when we see one we know it was probably not built before 1870 or after 1890. Later on, the Queen Anne style became fashionable, and multitudes of ugly houses of that order were erected.

Fashion prevails in the style of automobiles, and ultra-fashionable people buy a new machine every year or two in order to secure the latest style. A friend of mine drives a very excellent and satisfactory machine purchased almost new at less than half the original price because the owner discovered that the manufacturer had put out a car of practically identical construction but with windows of a different style.

People of moderate means drive a flivver of excellent construction at moderate cost. Thirty-five years ago there was not a millionaire in America that could ride as comfortably, or half as fast, as the ordinary citizen rides in his flivver; but owing to the popular ridicule of cheap low-powered cars the farmer soon grows discontented at driving such an inferior car, and if you count the automobiles parked on the street of any country village on a Saturday afternoon you will find that more than half of them are of more costly construction than an ordinary Ford. An American visitor at Stockholm last year observed nine automobiles parked together on a small public square. Seven of these cars were of American manufacture and only one was a Ford.

Similar laws govern other phases of human life. A few years ago no American thought of traveling third class on a steamship unless compelled to do so by poverty, but to-day thousands of students and professional people who might afford more expensive accommodations travel third class both by steamer and by European railway lines.

An illustration of the power of public sentiment to check violations of law is seen in the matter of souvenir collection. Not many years ago it was a common practice for travelers to collect articles of silver, table linen and other things belonging to hotels and restaurants and to exhibit them to a room full of friends, all laughing and joking about the cleverness which the souvenir collector had exhibited. This practice was not by any means confined to lower classes of people, but existed in a very considerable measure among those of excellent position in society. The practice may still continue to a limited extent, but no one of any social standing would dream of showing such articles to his acquaintances or admitting that they indulged in such collecting.

Application of These Principles to Law Enforcement

To a limited extent custom and fashion prevail in the matter of law observance, even where the law may occasion inconvenience or where it is contrary to one's natural prejudices. Ready obedience is given to health laws, whereby one's home is subject to medical inspec-

tion or to quarantine. During the great war and to a large extent since that time income taxes were paid with a reasonable degree of fidelity and cheerfulness. Laws designed to preserve the purity and wholesomeness of foods are being observed with increasing willingness as the community becomes more educated with reference to the advantage of those laws for the preservation of the health of the community. Laws regulating the care and removal of garbage are obeyed with increasing fidelity. An excellent example of the growing power of public sentiment in favor of obedience to law is seen in the great diminution of mob violence, especially in the south. This movement has been promoted by the voluntary cooperation of leaders in the white and black races for the education of public sentiment, assisted by the rapid emigration of Negroes to the north which threatened the farming industry in the south.

Duty of Public Officers

In order to promote obedience to law and to repress crime it is vitally important that public officers who are charged with the duty of dealing with criminals should themselves faithfully and scrupulously obey the law. It is a notorious fact that a considerable number of police officers, prison officers and even prosecuting attorneys do not scruple to violate law both officially and unofficially.

Take, for example, the practice which is known as the "third degree." It is a common thing for superintendents of police, official detectives and even ordinary policemen to subject accused persons, who may be guilty or innocent, to a rigid inquisition in which they are cross questioned, threatened and cajoled. It is not uncommon for this inquisition to be carried on for days at a time, for the prisoners to be deprived of sleep, and even subjected to physical violence. The writer made a careful inquiry into this subject in 1921 by means of an inquiry addressed to chiefs of police and prosecuting attorneys. Those who replied to the inquiry denied with one accord the use of physical violence, but most of them admitted and excused the use of prolonged and bitter cross questioning in order to extort information or confession; and a considerable number of prosecuting attorneys defended these practices on the ground that they were necessary in order to secure the ends of justice.

It is a well-recognized principle of law that every accused person is deemed to be innocent until he is proven to be guilty, and it is equally well recognized that no accused person can legally be compelled to testify against himself. In Great Britain, when an accused person is arrested, the police are required to inform him that any statements which he may make are liable to be used against him. In most of the states of the Union it is provided by law that confessions obtained from accused persons by force, threats or promises can not be used as evidence against them.

Notwithstanding these facts, multitudes of persons, innocent and guilty alike, are subjected to most bitter experiences, contrary to the laws of the land and contrary to the principles of human justice. Frequently such persons are kept incommunicado and are subjected to the treatment above described by irresponsible policemen and detectives.

We are informed that in France provision is made by law for the examination of accused persons, but it is done by a magistrate, and the proceedings are regulated by statute.

The writer has personal knowledge of the case in which a woman of high character and standing, coming from a western city for a brief stay in an eastern city, was accused of theft and was subjected for two days to a violent and insulting inquisition by two detectives. The facts of her character and standing could have been ascertained within two

hours by a telegram to the police of the city from which she came, but she was abused and humiliated to such a degree that it was difficult for her to talk about the experience thirteen years later.

The cruel and illegal use of the third degree is tacitly accepted by the public on the same theory adopted by the prosecuting attorney already mentioned, namely, that it is necessary in order to protect the community against criminals; but the competent and efficient police superintendents of Columbus, Ohio, and Berkeley, California, testified that third degree methods were entirely unnecessary and that they obtained more information and more reliable information without those methods than with them.

We believe that the time is speedily coming when public sentiment will no longer tolerate this medieval, inhuman and unnecessary practice.

Wherever the representatives of law and order themselves fail to exemplify the principles of law and order they become a force for the promotion of crookedness and crime rather than the promotion of public morals and the preservation of public safety.

Utilization of the Power of Public Sentiment

While force and fear may be recognized as necessary agents for the repression of that small portion of the community which is not amenable to those wholesome influences which restrain conscientious and patriotic citizens, is it not possible to utilize to a far greater degree than has heretofore been done those potent influences which control the actions of vast bodies of people in matters of custom, fashion, health and morals? Let the public schools, the churches, the press and all the leaders of thought and action unite in the effort to promote respect for law and obedience, not only to those statutes which fall in with the popular prejudices and desires, but also to those which call for self-denial and self-control, in the interests of the public welfare.

LAWS MEN BREAK AND WHY[1]

By the HONORABLE EDWIN M. ABBOTT

PHILADELPHIA

Since the dawn of creation man has fought against inhibitions of his freedom of thought and action. The association of people into communities brought with it the necessity of legal restrictions, but to certain individuals those restrictions have always been obnoxious and repugnant.

The tendency of modern legislation has been more and more to curb the natural predilections of man and has resulted in general confusion when authority has attempted to enforce such laws.

But the general antipathy to law enforcement is not confined to the present. It is only more general and more demonstrative.

There are so many laws that have been disregarded that it is time that something is done to ameliorate conditions. Man was never made good by legislation. He often behaves in fear of the law, and he sometimes obeys because of a desire to escape the penalty. Religion, patriotism, education and social conditions are more conducive to the higher morale of a people than all the laws of nations combined.

And it is individual selfishness that has developed a most dangerous condi-

tion. While the world is more charitable toward the needy and suffering, it has become obsessed with the demand for so-called "personal liberty," and as the wealth of this nation has been growing at tremendous leaps and bounds, with this accumulation has grown a disregard for law and the traditions upon which this nation was founded. Purists insist everybody must be pure. Liberals request every one to be liberal, and reformers in all walks of life endeavor to construct an Elysium which only the millennium can secure.

In ancient days when might was right, we had classes of all kinds. In modern times wealth and political affluence run riot through the land and we have again been segregated into classes. "Liberty" has been interpreted to mean "license" and "The Land of the Free" defined to mean, "do as you please with regard to others." The Golden Rule is gradually becoming emaciated. Therefore, men have determined that the laws of to-day which are obnoxious shall be disregarded and that most laws are made for the other fellow, anyway. Circumstances that control us under ordinary conditions are often forgotten and submerged in the desire for liberty, and so we face a general disregard of law participated in by individuals, collective groups and in many instances by states or communities.

Let us therefore consider certain laws which men will not respect and obey. The automobile laws restrict speeding, parking, lighting and rules of the road. Pennsylvania has a maximum speed of thirty miles per hour, yet automobiles are advertised to do fifty, seventy-five or even one hundred miles per hour and the owner endeavors to demonstrate that his car can attain such speed. He wants to go as fast as he pleases, drive wherever he pleases, park where he pleases and use such lights as he pleases, but the other fellow should respect the law in all particulars.

The crime of adultery might be eliminated from both sacred and profane literature. This law was never meant to be enforced in these modern days, and its usefulness is subrogated to the divorce court. It is but another restraint on personal liberty. And only in the divorce court do we have evidence that this crime has been committed. If you examine the records and read of the thousands of divorces that have been granted for this reason and then consider that rarely has a criminal prosecution been brought based upon the same facts, one must wonder if such an offense is really a crime.

In the state of New York adultery is the sole ground for absolute divorce. Yet how many inmates in the penal institutions of that state are serving time for that offense? The Mann Act covers the same offense under federal jurisdiction, but we all know that of the thousands of such transgressors few find their way into our courts. The criminal is only the poor fool who gets caught and can not adjust his differences by the monetary scale.

Gambling is another subject which touches the personal liberty of our citizens. In Pennsylvania gambling is not a crime. But certain kinds of gambling are. It is a crime to bet on an election, and while the penalty is not serious, everybody disregards this law and we never hear of prosecutions. The maintaining of gambling establishments, betting on horse races, being a common gambler and setting up lotteries or gambling devices are all contrary to law, but in the sweet name of charity some churches often recognize the innocent lottery and forget that every sale of a paddle or a chance on the sewing machine or cake is contrary to the law of the Commonwealth.

How many of us are conscientious in our returns to the federal government for our income taxes? We are instructed that our winnings at poker or other card

games must be returned as a part of our income, and that our losses should not be deducted. Have you ever met a winner who makes such a return? Are we honest with Uncle Sam in our return upon which our contribution to the support of the government is based? The commandment "Thou Shalt Not Steal" and the laws founded thereon are equally applicable to defrauding the federal government or an individual.

And that brings us to the crime of smuggling. It sounds like a harsh word, and we think of the pirates of old when we contemplate such a crime. But today it is a social event, as returning from a trip abroad with jewelry, fine linen and other purchases, the erstwhile "good citizen" contrives to get his booty home without paying the duty, and later, in the social circle he boasts how it came through with his political influence, or the tip to the Customs official. And this opens up the subject of bribery, which is such an extensive one that it reaches into many branches of trade and into every avenue of activity. Public officials seem to be the targets for bribery, and we should be thankful that most of our public servants do not succumb to the temptation. But citizens who want some favor or special privilege will not hesitate to go into our legislative halls, official offices or out into the highway and attempt by the use of money to secure what they desire. Have we carefully considered how the modern lobbyist secures special legislation? Does he always obtain votes by moral suasion—or argument?

The enforcement of the Volstead Act has opened many channels for the illegal use of money. Disregard of the Eighteenth Amendment, which is a part of our Constitution, and as much a part of the Constitution as the Bill of Rights, has led to the commission of many other crimes beside that of bribery. A most amazing condition has resulted to the body politic through the honest attempt in this city to enforce the prohibition laws. Perjury struts naked through our halls of justice, and disregard for the sanctity of the oath prevails in most of these cases. Public officials, police officials, magistrates, grand jurors, petit jurors and even some judges upon the bench forget that they are all sworn to uphold the Constitution and laws, both of the nation and the commonwealth, before they enter upon the activities of their office. Witnesses in court no more regard the oath as binding them to tell the truth, but use their testimony to their own advantage, irrespective of its truth or falsity. If jurors do not like a law they acquit defendants who are charged with transgressing it. If jurists find the law obnoxious to them they discharge malefactors convicted of breaking it. If police officials have been tainted with avarice and have fallen for a price, then memory becomes hazy and faulty, and so we have farce after farce enacted in what should be courts of justice.

There are many other crimes committed in the general disregard of law. The family physician, pressed to the limit by the exigencies of necessity, commits abortion to save the reputation of the daughter of the family which he has attended for many years.

The election official, ambitious to ascend the political ladder, takes a chance in disregarding election-law restrictions.

The so-called "good citizen" salves his conscience with exorbitant rentals of his real estate and does not consider the moral character of his tenant or the illegal purpose for which it is used.

The unthinking adult in the social circle or in the home disregards the restriction forbidding the furnishing of cigarettes to minors.

Blasphemy is still a crime, but you meet it at every corner.

The protection of health, sanitation, child-labor and factory laws to the minds

of many are impediments, and if one can forget them and evade them, well and good.

The Blue Laws are still upon the statute books. Many of them are relics of colonial days. Most of them are disregarded. Where is the legislator who will have the temerity to introduce a repealer for one or all of these acts, which are never observed?

The Narcotic Drug Act and the Pure Food Act are excellent pieces of legislation which many agree should be stringently enforced, and yet the drug addict is with us. The dispenser of such poison is only spasmodically run to earth. He even preys upon our school children and enters our homes and offices, increasing this nefarious traffic in many communities. We should be thankful that in this city a concerted effort has been made by our judges and police which has practically eliminated this terrible practice.

The pure food restrictions regarding adulteration or misbranding are evaded in many instances, and detection too often is punished with the imposition of a small fine. Seldom does any one receive a term in prison for this offense.

I might go on ad infinitum. The legislature decides we shall not have daylight saving, and individuals resent such action and do as they please. One state made it a crime to advance clocks or watches, and such an act passed the Pennsylvania Legislature in 1925, but the governor vetoed the bill. Last summer I passed through a state where changing of time-pieces constituted a crime and when I asked a good citizen if his clock was not registering contrary to law, his reply was, "Who pays any attention to such a law?" That seems to be the mental attitude of many citizens to-day.

The anti-trust laws are dying of dry-rot, and usury prevails in many garbs. The bonus is the most popular way of circumventing the six per cent. interest limitation.

Barratry and champerty are ancient crimes employed by the modern ambulance chaser, cooperating with certain lawyers and physicians. But all evade prosecutions for these offenses which they are continually committing and which are simply denoted unethical but not criminal.

Foretelling the future is also a crime, but our best citizens encourage these fortune-tellers and thus contribute support to another class of law-breakers.

I have only enumerated what must be but a partial list of laws that are only respected in the breach.

But, remember, for every policeman who accepts a bribe there must be some one who gives it. For every bootlegger who dispenses illegal beverages there must be citizens who purchase them.

The so-called crime wave is running rampant throughout the land. The populace is in hysteria in many sections. Murder, robbery, burglary, arson, rape, blackmail, kidnapping, larceny and kindred crimes are reported from every corner of this great nation.

The highwayman contends that all laws are alike and he will not respect the inhibitions against stealing. The foreigners in our midst do not respect our restrictions on his ideas developed in Soviet Russia or elsewhere and so he appropriates to his own use just what his perverted conscience demands.

How are we going to remedy this menacing and deplorable condition? The first thing to do is to try to reawaken the consciousness of all true Americans. When that is done we must act.

The first place to begin is in the home. Parents must set the proper example before their children. By precept and practice the youth of the land must be trained to walk in the paths of law-observance.

The foreigners within our bounds must be impressed with the fact that if they wish to enjoy the benefits of this great nation they must respect its laws, customs and traditions. If they refuse to do so, they should be transported back to the land from whence they came. Congress should broaden the laws allowing

us to deport all foreigners who become criminals before they have become naturalized citizens.

Every American should take advantage of the franchise. He should register and vote at every election and when public officials of any party are recreant to their oaths, they should be driven from office by a combined and determined electorate.

Every law-observing American should serve as a juror in the courts when called to that high duty. He should take his place in the grand jury room or in the jury box and see that even-handed justice is dispensed to both the commonwealth and its citizens.

When crimes are committed there should be prompt arrests, speedy trials and adequate punishments. Delays and red tape should be eliminated. Mercy should always temper justice but should not be abused. First offenders should be handled in such a way as to give them a chance for rehabilitation, but the recidivist, the confirmed criminal, should be segregated entirely from his fellows. He is a menace and should be safely interned.

The subject of adequate penalties is a most important one. The difference in Pennsylvania between misdemeanors and felonies is incongruous and means nothing from the present condition of our statute law. These differences should be abolished and all offenses should be enumerated as crimes. The more serious offenses should have more drastic punishments. Maximum penalties prescribed for many crimes should be increased.

The Ludlow Bill in Pennsylvania and all similar bills in other states should be repealed or modified and should not apply to any criminal except first offenders. The extension of parole to first offenders at the expiration of their minimum sentence should be under strict conditions, but no others should be discharged from a penal institution until they have clearly demonstrated their repentance and ability to return to society.

The system of probation and suspended sentence should only be exercised on behalf of first offenders, and those who continually break the law, especially in disregard of the liquor, food and other laws touching our social fabric, should not be allowed to escape with a fine or costs. A mandatory jail sentence should be written into the law for those who refuse time and again to obey it.

We should remember that a sentence is not only a punishment for the offender, but should act as a deterrent to others. It should serve as a reminder to all offenders to reform or take the consequences. There should be a revival of the double penalties for second and third offenses. This system is practically obsolete, although still a part of our statute law.

When prisoners are sent to penal institutions they should be given proper employment and compensation. There are many reasons for this. The most important are: To keep them employed and thus improve the morale of the institution; to teach them a trade or occupation which they can use when discharged. From their remuneration, the state should be reimbursed for the costs of prosecution and maintenance; dependents outside should be supported during the period of incarceration and a fund should always be accumulated to turn over to the prisoner at discharge for his use when he returns home and endeavors to live a law-abiding life. This would fortify him against temptation until he could secure permanent employment.

Drastic laws forbidding the indiscriminate sale of firearms and deadly weapons should be enacted and enforced. This is the most vital need of the present day.

And the pardoning power should only be exercised where extreme emergencies require it.

Could we awaken our people to the truth and make them realize that the future of America depends upon the sanity of the present we will still be in time to arrest this criminal outbreak and preserve for our children the grand heritage given us by our fathers.

HAS EINSTEIN KILLED TIME?

By Professor ALFRED C. LANE

TUFTS COLLEGE

THERE is an impression that somehow Einstein's theory has abolished time as a separate form of reality and made it identical with space. Has Einstein then removed time from the objective external world to the world of our own consciousness? If he has it may then be true that the facts which come to us from the outside world have already been to a consciousness which grasps four dimensions. As Tennyson's "Princess" thought:

To your question now,
Which touches on the workman and his work.
Let there be light and there was light: 'tis so:
For was, and is, and will be, are but is:
And all creation is one act at once,
The birth of light: but we that are not all,
As parts, can see but parts, now this, now that,
And live, perforce, from thought to thought, and make
One act a phantom of succession: Thus
Our weakness somehow shapes the shadow, Time.

This conception implies that, as Bertrand Russell says, "the time order of events is in part dependent on the observer,"[1] or indeed, as we read in Steinmetz's "Relativity," "Time and space have ceased to be entities and become mere forms of conception."[2] Note the word "mere."

But to us even so not all is present. To the plane of our consciousness the past and the future are not the same. But what is meant by "plane of consciousness"?

Suppose we have a little crystal under a rather high-powered compound microscope. We will see only that which is in the focal plane of the microscope, and if there is an edge inclined to the microscope's focal plane it will appear as a dot, which as we focus up and down seems to change its place. There is still real motion, but not of the dot; the motion is of the focal plane.

In the microscope we see successive planes one below the other. In a moving picture we see successive films as the picture brings them one after another into view. In the moving picture things appear to move in the picture, but it is really the machine which is moving and bringing into view a series of pictures, in each one of which there is no motion, one following the other so rapidly that they seem but one to our senses. But note that in both cases there is a real change in time, and a real motion though not just that which seems to take place. In the reel all the successive stages of the motion coexist.

It is, then, perfectly possible to conceive with Einstein that all physical events, past, present and future, are equally events, but that they are not all in the focal plane of our consciousness. Thus as the apparent motion of the edge of the crystal is due to change in focal plane, so the apparent motion of a falling body is due to our being successively conscious of different positions.

One may reply that the focal plane of a microscope has a certain depth. It is not an absolute plane. Things gradually come into focus and gradually go out again. The reply is that it is so with our own consciousness; otherwise, we

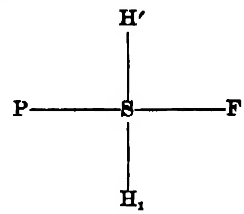
[1] "The A. B. C. of Relativity," page 44.

[2] Page 12.

should not see a color as such, for a color depends upon the time of vibrations, which are long if we are measuring them in units of the X-ray vibration. And again we should not hear a sound as such, for a sound is due to vibrations which take still more time. In other words, the present as a physical fact has a certain duration. It is then clear that we can at least conceive of our consciousness as becoming acquainted with successive belts in a four-dimensional universe just as in the case of the microscope we become acquainted with successive planes of a three-dimensional universe.

If, however, we analyze the difference between time and space, we find that time refers to change. This can only take place in time. So the minute that Einstein in his mathematics introduces the idea of change (as he does by the letter d), he is introducing the idea of time (that is, of change). On the other hand, space comes to us from the idea of coexistence. We get from what we see a form, and that form exists not by change but by coexistence. From a point there are various coexistent directions, that make angles with each other. Those angles exist independent of the number of coordinates or the number of dimensions supposed to exist in the universe. They exist in Einstein's four-dimensional universe as well. There is, moreover, no reason in mathematics or philosophy why we should stop at four dimensions, nor why we should not have five, six or seven. An angle would be still an angle. It is the great merit of Einstein that he has shown that certain actual facts of the world can be explained by the use of our dimensions. But there is no need of stopping at four. Another great savant a century hence may find facts that call for five!

I one time amused a colleague by suggesting that we add a moral dimension and represent with Einstein the past to the left (P), the future to the right (F), with Heaven above (H′) and Hell below (H_1), while the three dimensions of this present world space are supposed to be in front at right angles to them and each other.



It will perhaps strengthen our argument and make one point clearer if we consider what a change in a four-dimensional universe would mean, first, if we suppose that it is purely objective and that our consciousness is aware of but a three-dimensional film of it at a time. Secondly, if we assume there is no other time, we will try to see what is implied.

Einstein assumes no such change in his four-dimensional universe of events and therefore reduces all problems of physics and mechanics to geometric ones. This is a helpful device mathematically, but there is no more logical necessity for this than there is of limiting the number of dimensions to four. Now suppose a change in the four-dimensional universe. If time is not solely a function of our consciousness this would simply mean that another world consciousness than ours would find things different from what we had found them, or that the future when we are aware of it will be different from that which one would now prophesy.

This is conceivable and believable, must indeed be believed by those who think there is a real uncertainty even in God's mind as to what we shall become. Einstein's static four-dimensional universe implies theological fore-ordination, if there is a God.

On the other hand, if we suppose there is no time but the Einstein fourth dimension, then a change in the four-dimensional universe will mean that the future will later be different from what the future now is. Conceivably we could at least try to believe that, but could we also believe that the past will have been different from what it now is? I for one can not admit the possibility that, whereas, the Declaration of Independence was on July 4, 1776, some time later it will have been on June 17, 1775. Mind, the question is not what will prove to have been, but what it really was. I can but agree with Fitzgerald:

The Moving Finger writes, and having writ
Moves on: nor all thy Piety nor Wit,
Shall lure it back to cancel half a Line,
Nor all thy Tears wash out a Word of it.

If we assume otherwise it would be possible to say that in the Middle Ages the world would have been created by God in six days, and now it has been created in as many billion years. In the time of Dante a man might truly be bound for a literal heaven, or a literal hell, and now there may be no such place. Because I can admit the possibility of believing the latter, but not of believing the former, there is in my mind a difference between the past and future, which does not come out in Einstein's theory. Thus whether recent observations of Miller which affect the basis in facts of Einstein's theory are confirmed or not, I can admit it only as applying to the world of events which we experience in succession, and I see no reason why it should clip the speculative wings of the mathematician or philosopher, except in so far as a basis in observation indicates a static universe and supports a deterministic philosophy.

THE NATURE OF SCIOSOPHY AND SCIENCE

By Dr. DAVID STARR JORDAN
STANFORD UNIVERSITY

SCIOSOPHY is systematized ignorance. Its nature was indicated more than three hundred years ago by Giordano Bruno, in Florence, who for varied heresies, for example, denying that anything was in the heavens above except space and stars, was soon after appropriately punished. "Ignorance," says Bruno, "is the most delightful science in the world because it is acquired without labor or pains and keeps the mind from melancholy."

The word sciosophy was coined by me in 1899 to meet a long-felt want. Sciosophy in action is called magic; latent magic is mystery. It differs from ordinary science in its basis. It is not derived from tested and verified human experience, because life is short and humanity demands quick returns. It recognizes no relation of cause and effect, for these are mere human devices. Instruments of precision, logic, mathematics, the telescope, the microscope and the scalpel, are not needed in sciosophy. Its processes are instantaneous and intuitional, while all scientific testing is slow and laborious. It is indeed folly to wait for this, when tradition, memory, impulse, imagination are all at hand pointing straight to truth or at least indicating that one conception is as good as another, if not better.

Sciosophy is of two classes: the one solidly based on tradition, which is our record of the guesses made by able men of the past, who labored without instruments of precision and who knew only what they thought they saw, and who tied their successors up to it. The other, having its base in imagination, knows no bounds save in degrees of vividness. The first tends to identify itself with religion, which it envelops in a cloak of mystic mist, making a merit to believe for belief's sake. The other type of sciosophy tends to make light of religion and to scoff at whatever our fathers have deemed sacred.

My interest in sciosophy, or more exactly in creating a word by which to define it, was provoked by a volume called, in English translation, "Posthumous Humanity, a Study of Phantoms," by Dr. Adolphe D'Assier, of the Academy of Sciences at Bordeaux. In this work are given many illustrations of the spontaneous activity of shadows and especially astral doubles. It is, in fact, a complete "fauna of the shades," in which are included all manner of wraiths, ghosts, shadows and phantoms, some of them wolf-like; some the ordinary astral doubles, with others due to the powerful expulsory force of the sun.

It is now well known that all animals and plants are built up of cells or chambers, each one charged with magnetic life jelly or protoplasm. These cells are never completely filled with this substance, which is in reality a vivified network, like a skein of tangled yarn. Into the cell with its network the odic forces of the universe penetrate and by their entanglement and permeation build up within a form corresponding in all respects to that of the object as a whole. It then becomes its double or negative, technically known as the "astral body," being solid only when the cell is empty and empty when the cell is solid.

The greatest interest attaches to human phantoms and especially to the activities of shadows, the most abundant creations of the shades.

A most remarkable case is that of Herr Peter Schlemihl, of Kunersdorf in Germany, as related by the noted Baron Adelbert von Chamisso, himself a man of science, the discoverer of our own California poppy, to which he gave the romantic name of *Eschscholtzia.*

It seems that Herr Schlemihl was once approached by a stranger, graybearded and dignified, in fact a Master of Arts. This gentleman expressed to Schlemihl a desire to purchase his shadow. A high price was named and promptly accepted. Thereupon the stranger knelt on the grass, rolled up the shadow, folded it neatly and thrust it into his knapsack, disappearing down the road between two hedges of roses, leaving Schlemihl himself absolutely shadowless.

At first the poor man thought he had made a good bargain, but afterwards whispered words and doubtful glances warned him that he was marked as a shadowless man. His anxiety soon gave him real discomfort. He set out in search of the shadow, and after many adventures he overtook the grave and serious individual to whom he had sold it.

But neither offers of money nor blows of the fist availed anything. To the former the stranger turned a deaf ear, and to the latter he used the shadow for protection. To struggle for it only served to damage the precious article itself. When Schlemihl died at last it was noticed that he left no wraith to rustle through the old graveyard at Kunersdorf.

The baron who relates this story remarks sagely that "an event had taken the place of an action, as has happened not infrequently in the world's history." This cryptic utterance is of itself typical of sciosophy. If one meaning does not satisfy, hunt up another. In Schlemihl's days such events were usually ascribed to Satan. But sciosophy now gets along without him (or with him, as the case may be). At the most he is but a "fabled fancy of an older world, the fluidic phantom of effete orthodoxy." The fact that the stranger was dressed in black, which by transmitted light looked reddish, and that his breath exhaled a faint sulphurous aroma favored the common superstition. A highly concentrated odic aura probably accounts for this. Most such concentrations have a residual odor of sulphur.

A rather well-authenticated record of the separation and independent life of a shadow is given by Mr. H. C. Anderson, of Copenhagen, a careful observer of occult phenomena. It appears that a Danish country gentleman of good family once lost his shadow. This did not worry him much until his strength began to give way and his clothing grew alarmingly brittle. Still worse, while confined to his room, he got wind of strange pranks performed by his double who seemed trying to undo him by ridicule. At last the phantom usurped his master's place at the head of the table. After this, in burning indignation, by a supreme effort of the will the gentleman recalled the phantom, to the endless mystification of the guests at the function. After this effort, his vigor returned and his new suit ordered direct from Rosenstein in Copenhagen showed no deficiency in stamina.

During the World War many appearances of wraiths are recorded. But in these disturbed conditions they might be confused with ordinary shadows, the condition of the human mind amid the glories and crudities of war being opposed to sceptical accuracy. One incident, however, vouched for by the highest authority, comes to the front and demands explanation. A well-known

lady in Los Angeles, driving along one of the many suburbs of her city, noticed on the street corner a man of unbelievable shabbiness. His manner matched his attire, and the kind lady stopped to inquire concerning his evil plight. Then there suddenly appeared on the sidewalk an elegantly dressed lady, "tailor-made" as the phrase is, who in agonized tones shouted, "Don't let him do it! Don't let him do it!"

Inquiring as to what he proposed to do, he said that he was penniless and hopeless and on his way to drown himself in the sea. The lady gave him some good advice, and still better some good money. The tailor-made lady had suddenly vanished. The beggar had not seen her at all, it appeared, but from the description he recognized his own mother, long since deceased. This incident shows that the wraith, so long a matter of pious belief, is in reality a scientific fact.

This incident also gives the clue to the remarkable fact that a wraith or detached astral body wears astral or phantom clothing. All wraiths thus far recorded appear to be properly dressed, else indeed they would be rushed by the police. The facts in this case are easily explained by the astral substance which fills the cloth cells of all garments. Phantom men wear phantom clothes, else their appearance would shock even the adept, a large percentage of adepts being ladies.

It will be remembered that in the war at Mona in Belgium the figure of an angel appeared in the heavens, seeming to urge the heroes in the trenches to "carry on." Officers and men agreed as to this vision, and none would confess that they had not seen it. After the incident had passed into history, a London humorist boasted that he had invented the "Angel of Mona" and showed documents to that effect. But the natural sciosophic answer was if his talk were really true, it was the same angel, who inspired his story, thus giving the needed publicity, for there are few adequate channels of communication between this world of confusion and the unchanging stars. The vision of Constantine, *In hoc signo vinces,* which changed the history of all Europe, at once comes to mind as the forerunner of the Angel of Mona.

Referring again to the classical work of Dr. D'Assier, he has conclusively shown that even inanimate bodies have their doubles or phantoms as well as men and beasts. It is a matter of ancient observation that cliffs and trees show shadows as distinct as those of man. The "shadow of a rock in a weary land" is classical. That shadows may be detached and yet hold a sort of life of their own is well authenticated. In a curious tale by one Barrie, of Edinburgh, a boy called "Sentimental Tommy" in running once turned a corner so suddenly that he "dislocated his shadow." It is easy to see how such an accident might occur, though not frequently. One R. L. Stevenson, also a Scotchman, tells of a boy who lost his shadow and of the embarrassments he naturally met in consequence.

There is no doubt, therefore, according to the followers of D'Assier, that the shadow of a man or a tree is an objective reality as much as man or tree itself. Phantoms are driven from their original status by the expulsory force of the sun. "The huge conical shadow of the earth which reaches beyond the moon and is called night" is not merely absence of light. It is a stark reality and for all we know may help to hold the moon in place. Its appearance marks the hour of phantoms when the odic and fluidic forces of the earth are concentrate. It is natural that about midnight should be the clustering time of phantasms of all degrees, and so it is. In daytime a shadow is seldom seen far from its host.

Towards evening, however, it asserts itself, stretching more widely, and in sleep it often becomes altogether detached, to be more or less painfully recalled in the morning.

According to D'Assier, after the death of its host the shadow wanders freely and at will. But not for long. The stars, arch enemies of shadows, soon begin to breathe and drink it up—"l'aspirent et le boivent"—and in ten to twenty days it is reduced to primeval vapor. The ever-present fear of dissolution often causes phantoms to become violently excited. In spite of their freedom to move they tend to linger about original haunts. In a few cases they find a means to suck blood from living creatures, thus, as vampires, maintaining a precarious existence. It is asserted that the swift remedy for vampires is cremation. The testimony of peasants in Little Russia bears this out, and it is plain that once drawn into a current of hot air, no phantom could ever regain its pristine form. For this reason, burning at the stake was preferred in the Middle Ages to other penalties for lack of conformity. To this fact the choice of the stake was made as the safest method with which to deal with Bruno, as with Latimer and Ridley and Servetus.

At the best the shadow's span of independence is short. This is "a wise provision of nature, for otherwise the earth would be solidly full of shadows." "The accumulation of specters of the terrestrial fauna heaped at the surface of the globe since the first geological epochs would render the air irrespirable. We could not breathe a dense atmosphere of ghosts." This is the conclusion of D'Assier, and chemical analysis of air in different localities seems to bear out his conclusions.

Unlike materialistic science, which rests on mere sensory contact, sciosophy has a foundation of principles.

First, matter rests on mind. On mind it depends for recognition which is its sole existence. Its alleged laws are mental channels only, the grooves through which the spirit passes. With your will you can cut such grooves. You can frame your own laws.

The crude notion of cause and effect, so cramping to material science, is cast aside in sciosophy. Its propositions are proved by inversion, a simple process unknown to materialistic logic. Thus the great founder of Neminism asserts: "There is no pain in truth, therefore there is no truth in pain. There is no nerve in mind, therefore no mind in nerve. There is no matter in good, therefore no good in matter."

The motto of this cult, *"Nihil nemini nocet,"* is a fine illustration of the method, as in the expressive Latin the words can be arranged in three ways, always expressing the truth; thus "Nemini nihil nocet," nobody hurts nothing, proves the original thesis; nothing hurts nobody. It is rightly claimed that sciosophy is at once the complement, the opposite and the antidote to material science.

The clean-cut quick methods of sciosophy appeal to many outside the inner circles of the cult. To get there quickly is better than to wait for a generation or two. Wherefore some devotees of the most exact science have used the "running high jump," a technical term for speculative philosophy, in matters in which the old system of trial and error seems unbearably slow.

To advance by quick methods towards the infinite is one of the temptations alluringly held out to exact sciences. An aeroplane moves more swiftly than a goods van, though it may carry less weight. And while art is long, time is fleeting, and to reach finality in a lifetime is a great aim of sciosophy. If external nature has no objective existence, and one thing is as true as another, this

method of enlivening "funeral marches to the grave" is, as Bruno observed, most satisfying.

A fascinating phase of sciosophy is disclosed in the effort to probe the soul of the atom or to gauge the conscious feeling of a chopped tree. If an atom has existence, it must have a soul around which experiences cluster. If it has no existence, all the more need of a soul. If the universe is alive, and whatever is alive has feeling, why not atoms, crystals and grains of sand, as well as frogs and men? Marvelous are the achievements of the "Synthesis of Life," not a laboratory job, of course, but a task for the adept who creates life through juggling words, thus producing "a reasoned synthesis of the fabrication of protoplasm," even if he never sees protoplasm itself.

Sciosophy, as history tells us, was the basis of the wisdom of the Middle Ages. The divine right of the church, that of the king, and in later times the divine right of the state rested solidly upon it. Its basis can not be too solid, for without mystic privilege or divine intervention the modern state would be deprived of its most extensively practiced right, that of taking the lives and property of its own people in order to destroy the lives and property of other people across its borders. If you take the doctrine of science that the state is a combination or giant corporation for mutual benefit, in which each individual in some degree should be a gainer, the state has no more divinity than the wheelbarrow. Each alike would be a device for mutual help or general convenience. Under this view the time-honored formulae—the king can do no wrong, the church can do no wrong, the state can do no wrong—would dwindle into insignificance. "Hundred per cent. patriotism" and "My country, right or wrong" would lose their sacred meaning. The tested results of human experience, which are the basis of the grim philosophy of democracy, all tend towards the rule of the unfavorable mob.

In the early days of European civilization, it was the custom to follow a battle with a feast, in which the wise old men of the victors should eat the brains of the wise old men among their opponents, and the strong young men would correspondingly eat hearts of the strong whom they had bravely slain. It was a fact unquestioned that eating brains promotes wisdom, as eating hearts is known to strengthen courage. In fact, it was freely stated that but for the necessity of this bracing up of the wise and strong, there would be no purpose at all in going to war. But sciosophy remedies all this by going back to first principles. There is of course no other reason ever for going to war except that offered by divine sciosophy.

The patriotism peculiar to sciosophy is thus stated by Anatole France:

> We shall always be victorious; patriotism makes it a crime to doubt. To take up arms is to the nation's spiritual interest; even war never enriches more than a certain few. It is enough to beat the drum, wave the flag and the enthusiastic crowd rushes on to carnage and death.

In political economy, sciosophy still rules the world. It requires neither telescope nor microtome to ensure its primacy. As a nation we have been prosperous, and this according to sciosophy is due to the tariff. We have taxed ourselves rich. This we may prove best by inversion. To use war as the means to settle disputes is perhaps the greatest triumph of sciosophy. War leads to peace, for when nations are thoroughly exhausted it takes years to fatten them up. Therefore war-making is the surest means to bring about peace. This truth is proved by inversion, as peace is the surest road to war.

The most useful weapon devised for war is forged by sciosophy. It is "impersonal hate," the hatred of strangers.

Its truth is again proved by inversion. Let us assume that we call our military opponents Huns. There is no Hun in good, therefore no good in Huns.

It is said that the thirteenth was the greatest of all the centuries. In this enchanted period, learned men knew everything, or at least all that was worth knowing, for the world they lived in was a sink of iniquity soon to be destroyed and only by the blasphemous and impious, ranged with the pure planets and the eternal stars.

It was left for modern times to confuse their wisdom, to drag the purity of celestial conceptions into terrestrial mud. Not content with supplanting the divine power of direct action by Newton's law of gravitation (an effort to crowd the Creator out of His universe), they have set aside the "fall of man" by the thesis of his "ascent from the brute." The protest against this additional disturbance of predigested opinions was finely voiced some years ago by a group of sciosophists in South Carolina.

"Resolved, that Man was created by an instantaneous process without previous animal parentage." Quite recently a similar cult in Texas "reaffirms its historic stand that Adam's body was fashioned out of matter previously created out of nothing." Either of these in a single sentence, as compact as any of Lyell, Darwin or Huxley, elucidates the origin of man. And if necessary the same truth could be proved by inversion. There is no man in animals, therefore there is no animal in man.

A definite assertion like this at once clears the air and closes the door against future heresies. For nearly two hundred years the famous dictum of Archbishop Ussher had held its ground. "Heaven and earth, center and circumference, were created all together in the same instant, with clouds full of water, on October 23, 4004 B. C., at nine o'clock in the morning.

In an essay attributed to Lord Bacon, the story is told of the effort on the part of a cult of priests to find out how many teeth a horse has. Appeal was made to the Fathers and to Aristotle, but without result. Finally some one suggested looking at a horse. This was fiercely resented by the scholars. "Satan hath tempted this bold neophyte to declare unholy and unheard of ways of finding truth, contrary to all the teachings of the fathers." The disputants finally declared it to be "an everlasting mystery, because of a grievous dearth of historical and theological evidence thereof and so ordered the same writ down."

This incident has an importance in sciosophy which does not appear on the surface. It is not a matter of horse's teeth alone, but of the great principle on which traditional sciosophy rests. If we allow an appeal from authority to observation and experiment in one case, we shall be forced to do so in all. Authority would cease to be a pillar all men could lean against. Luther's appeal to "private interpretation" of the sacred books would be applied to all philosophy, theology with the rest. To "private interpretation" we owe the splitting of religious organization into hundreds of cults or denominations. Spreading its destructive influence, everywhere in human relations, it threatens most disastrous results. It has brought them on already, and even a great unifying war can not reclaim the fragments.

No discussion of sciosophy could be complete without recognition of its immediate personal values. In the words of the man on the street, "there is a good deal in it." That is one reason why its beneficial influence so long endures. The witchhazel rod is to many the staff of life. In the West, where witchhazel does not grow, any other crooked stick (especially of a tree that has water in it) will serve as well. Or the divining rod can be made of metal. If the territory is

too great to be traversed step by step, a small metallic rod may be passed over the map with equal success.

In the rush to the Klondike thirty years ago, the vender of the rabbit's foot grew wealthier than the washer of pans of gold, especially if his quarry were obtained in a country graveyard in the dark of the moon. At the present time industries based on sciosophy, such as astrology, palmology, horóscopy, kleptomania, pluviculture, and the like, are especially repaying. In our leading dailies "What the stars predict" and "What the planets tell" divide space with the "Dawes Plan" and the latest murder. In to-day's newspaper I read that "this is an unlucky day. . . . The seers predict the coming year will be as marked by vice and crime as 1924. It is possible for men to attain true greatness through science. There will be new wonders performed. Children of super talents will be born before the middle of the century. Children born on this day will be extremists, either for good or evil."

In our day, war lifted the lid on society, and secret actions and beliefs held in the dark now dance openly on every green. For the aftermath of war is the heyday of temperamentalism and of forty thousand other isms, social, political or religious, soothing to the soul and requiring no effort of the mind or hardening to the hands to secure them. "To live in two worlds at once" or in one "world with four dimensions" far from the distractions of realities is now an ideal easily obtained and earnestly to be desired.

Authority, on the one hand, a pillar to lean against, and sympathy on the other, a bosom to weep into, these are the chief demands of humanity in the mass. Both these sciosophy can furnish in full measure. No instruments of precision are necessary to set up authority or to set free the fountains of the soul, and these once flowing know no limitations of time or space. Esoteric dreams solace the future; absent treatment is better than present medicine. Its defiance of materialism proves its spiritual value. Sciosophy is ennobled by being set to work. "To cure men of all ills whatever," says a high priest of the Neministic cult, "we have only to show them the stars. When we waken in the night only the sight of the stars . . . can tell us that we are awake. When we are awake all dreams must vanish, and all is dream which breaks the serenity of the mind. . . . We need not deal with the body for the body does not exist. It is dull, heavy and aching because it is dead residuum of dream. When we forget it it is no longer there. . . . " To this in the cryptic fashion characteristic of sciosophy is added this great principle: "The equipollence of the stars above and of the mind below shows the awful unreality of evil." And as to this proposition one can have no reasonable doubt. The paragraph just quoted ends with a sudden dash of worldly wisdom. With perfect faith in the unreality of external things it matters little what the practitioner does or leaves undone. Though money has no real existence the shadow in its substance proves that there is substance in its shadow. "The population of our cities," says the high priest lately quoted, "is ample to supply many practitioners, teachers and preachers with work. To enter this field of labor beneficially to ourselves it is necessary to demonstrate that the patient who is able to pay for being healed is more apt to recover than he who withholds a slight equivalent for health." Thus he who has paid for a tonic pill of crushed lion's mane (clipped from a setter dog), or for a touch of an old bone of a king or a blessed handkerchief, or for repeating "To-day, to-day, in every way, I am getting better and better," is more likely to keep his faith than one to whom such favors come unasked. It is human na-

ture to try to get the worth of one's money. And after all, what is money as compared to health? Health is a spiritual condition not to be brought about by doctors with their pills and poultices, but an inevitable result of an adequate faith such as would move mountains.

Chemistry arose from the earnest study of alchemy, the change of base metals into gold; so has the art and science of modern medicine arisen from a branch of sciosophy. There was a time when every disease had a remedy and when the healing value of a new plant was indicated by its looks.

Another phase of this doctrine is that those drugs cure a disease which reproduce the symptoms of it. "Similia similibus curantur." And if a drug is a sure cure, a little dose is as effective as a big one; in fact neither disease nor remedy is real, and the "absent treatment," which is nothing at all, is as good as anything else if not better.

And medicine, like theology, having no recognized basis in science, split up naturally into cults. And so long as sciosophy holds its grip on the masses, so long will these cults find remunerative play. So long as "ignorance is the most agreeable of all sciences, because to secure it demands neither agony nor effort," it will be in constant demand.

I need not undertake to contrast science with sciosophy. Science is classified knowledge, no more, no less. The cardinal principle of science is that we know nothing until men find it out. There is no authority under heaven or above it that can give answers in advance to any question of fact. *"Roma locuta est, causa finita est,"* closes no scientific investigation. Science is human experience, tested and verified by our instruments of precision, telescope, microscope, scalpel, spectroscope, and those finer instruments of the mind itself, memory, logic and mathematics. Once its facts are obtained, they must be set in order. They must show relations of cause and effect, else they lead nowhere. "Facts are stupid things," Agassiz used to say, "unless they can be combined into truth," and to become truth facts must be stated in terms of human experience.

I have thus given, I trust, not unsympathetically, a few concrete examples of the most varied and most widely spread of all philosophical systems and the one most comforting to the human soul. Only a gigantic cyclopedia could tell the whole; I can only touch the fraying edge of a huge mantle which has enveloped humanity since it tasted its first knowledge of good and evil. It ranges throughout the universe from the cure of toothache and heartache through all the clustering multitudes of stars to its culmination in the ineffable, mouth-closing syllable of OM. This opens the portal of Nirvana, which is nothing at all.

In my own view the goal of human evolution is found in no single syllable, but rather in reason, religion and love. The central axis of these is reason or intelligence. Through the intellect, love and reverence are raised above the level of instincts. Each has its primal origin in simple relations. Intellect arises from reflex action, a complexity of tropisms. Love looks forward to the continuance of the race. Religion finds its initiation in fear and awe, culminating in reverence and duty. Each of these in its exalted reaches is upheld by intelligence, its organ of vision.

The term *reality* is used in psychology to denote impressions on the mind or nerve center due to the impact of external impulse. It is an objective impression as distinguished from a subjective condition. Subjective appearances of reality seen by "the mind's eye" only may be illusions. An illusion at bottom is usually a fading memory, a

continuance of a reality after its source has passed away. An untruthful interpretation of an actual reality is a delusion. Delusion and illusion form the subject-matter of sciosophy as reality forms the basis of science.

In the reality of the objective world, the integrity of science and sanity of men are alike bound up. The distinction between objective and subjective, between reality and illusion, between fact and fancy, between presence and memory, between reason and tradition, all fundamental in human psychology—each is essential in human conduct. Truth is livable and error is not, a difference which appears in the stress of the conduct of life.

The power to summon up adequate truth from our realities is called common sense. Science is only common sense expanded and verified and applied to a wider range of objects. With its instruments of precision (mind, memory, logic, mathematics and its accessory tools) it goes beyond the obvious into the hidden complexities of truth. The final test of truth is its "livableness," the degree to which we may trust our lives to it or to the methods by which it is won. It is not merely "workableness," for an idea false or incomplete may be workable in a degree. Many elements of sciosophy are workable, if not put to an acid test. That one man or ten million men get along with an idea or a dogma does not argue its soundness, unless these men have successfully translated it into action.

The relation of science to human life is in main threefold: first, to help humanity by its control of sanitation, conservation and the use of the forces of nature—this is applied science; second, to furnish a sound basis for the conduct of life—this is the art of ethics, and right living can fall back on no other authority. We must not trust to impulse or instincts, for the power to control and to discriminate among these is the function of intelligence. We can not trust to religion, for the sentiment of fear, awe, reverence and duty is sadly overlaid by superstition. It is for science to combat superstition and to disentangle religion from its meshes.

The third function of science is to widen the human mind. Its span is the universe, dealing with the infinite great as with the infinite little. We can reach a small part, not a fraction but a tangible fringe of a universe in which there is neither great nor small. We find in it endless change, but every change is orderly. So far as we can see, "nothing endures save the flow of energy and the rational order that pervades it." This intelligence we can not describe nor circumscribe. We can not speak of it in any terms of human experience, and to try to do so shows only the narrowness of our conception.

SUPERTHOUGHT

By Dr. ARTHUR EDWARD RUARK
YALE UNIVERSITY

One of the chief glories of the human intellect is that we can easily recognize the assumptions on which thought itself proceeds—the so-called postulates of logic. It never occurs to most of us to question those assumptions; to do so is not "common sense." But it is well to question them, because by so doing we shall arrive at extremely important results—results which lighten the labor and clarify the vision of the student of nature as well as the philosopher.

In this article we shall show that the nature and methods of our everyday reasoning are based on the physical laws of our universe, and up to the present have been seriously limited by those laws. We shall find that the mind can conquer these limitations and can deliberately set up for itself new modes of thought which have little in common with those of our fathers. Our ordinary thinking is only a special case of a science we shall call superthought until a better name is suggested. We shall discuss briefly some features which are common to all the systems of logic which are contained in superthought, and shall point out that certain great problems of philosophy are probably insoluble in terms of our normal modes of thinking.

Let us begin with a simple example to see how the structure of our logic is controlled by our physical experiences. Suppose we look at two objects A and B and find that A is like B in all respects save that they occupy different positions in space. Now let us compare B with a third object C, arriving at the conclusion that they too have the same properties. It does not follow that on comparing A with C they will be found identical. True enough, A and C have turned out identical in all cases which have arisen within the memory of man, but if we found in some instances that A and C were quite different, we should not be in difficulty. It would be an exciting game to investigate the new laws of nature—to determine under what circumstances A is C; under what other circumstances A is not C; and in cases where A is not C, to find out in what ways they differ.

The reader should look before he leaps if he feels inclined to dissent. Suppose he says that we have arrived at a contradiction; that on comparing A with B a second time we should find them dissimilar. There is no objection. It may very well happen that on performing this fourth, *absolutely independent* experiment the result will be different from that of the first comparison of A and B. The result depends entirely on the properties of space and time in the universe where these experiments are performed. We admit at the outset that such lightning changes in the essential nature of objects would be disconcerting until we learned the underlying principles upon which they depend. After all, it might be just as easy to follow the vagaries of such a universe as to understand a world in which one bacterium can start a plague and decimate a nation, or a trivial "international incident" can soak whole continents in blood.

A colony of human beings in a universe with the peculiarities described above would so mold the fabric of their thought as to cope with the situation automatically. To them the new laws governing the behavior of objects would come, in the course of a few generations, to be laws of thought. The behavior of objects in our actual world would seem to them "impossible," "incomprehensible" or even in some cases "self-contradictory."

The syllogisms which would be constructed in the new universe have a strangely unfamiliar ring to terrestrial ears. Returning to our former example, suppose that the law concerning the similarity of A and C were this: A is C from 6 A. M. to 6 P. M. but A is not C in the other twelve hours of the day. A typical syllogism would read as follows:

A is B,
B is C,
It is half past nine in the morning,
Therefore, A is C.

Such syllogisms would afford wise and convenient rules for the conduct of life in the new universe. The changes taking place at six o'clock would appear as natural to the dwellers in that universe as sunrise and sunset seem to us.

In conclusion, *the laws of logic are fundamental regularities of nature, not of mind.*

Up to this point our attack has been directed against the nature of the reasoning process. We turn now to overthrow the seemingly absolute and unchangeable character of the simple statements which form the raw material for the reasoning process. Stripped of all accessories, a simple statement is to be regarded as the symbol for a mental comparison of two objects, or of some quality of two objects. All our perceptions seem to be expressible in the forms, A is B, or A is not B. We shall concern ourselves with the consequences of the fact that the statement "A is B" is a little too strong, regardless of what A and B may represent. All that a single conscientious observer can say is, "A appears to me to be identical with B." Coincident testimony from a number of observers can not change the situation. We can never be certain that another group of observers will register the same opinion as the first. All the color-blind men in the world would call a red dress and a green dress similar. A *deus ex machina* is required in the shape of a person with normal color vision to set them right about the way things appear to the great majority of people. Perhaps a still more capable *deus*—a departed spirit, for example—could advance very cogent and subtle arguments to show that red is identical with green.

The moral of this extreme case is, *similarity and dissimilarity depend as much on the observer as on the thing observed.* We can not say in the last analysis whether one observer or one method of observation is "better" than another. The result is that we lose all basis for the comparison of objects. *Objective reality has no meaning until we specify the observer.* The philosophic arguments which center around realism and idealism are frequently valueless because of failure to specify at the beginning the essential qualities of the observer.

To give a concrete example: in the days before relativity it was believed that the length of a rod would be the same when measured by an observer at rest as when measured by an observer in motion along the rod. To-day the physicist tells us with all solemnity that when the experimenter is moving rapidly all bodies appear to be shortened in a direction parallel to the line of motion. The statement "This stick is a yard long" is true only for an observer moving in a certain way with respect to the stick. Nearly the whole essence of the theory of relativity, as far as its philosophic implications are concerned, is that it shows exactly what types of physical quantities are assigned the same value by observers moving in all possible ways, in all portions of space and at all times.

Now an object may be existent as far as one of our senses is concerned, but non-existent for another. Existence depends on the mechanism of perception and is wholly relative. We can not make much progress in devising ways and means for generalizing our modes of thought by supposing our senses perfected. That simply throws the problem

one step farther back in an infinite sequence of steps. It raises the questions connected with the existence of an omniscient being, which probably can not be solved in our ordinary modes of thought.

We arrive now at a very important question. *Is it possible that for a given observer an object could both exist and not exist, at the same time?* Of course this is impossible in our universe, and two reasons for this impossibility suggest themselves.

First, the impossibility may be due to the imperfections of our senses. Second, it may be due to some cause inherent in the structure of the universe, having nothing to do with our personal limitations. But it is the author's opinion that these two causes can not be rigorously distinguished for the simple reason that we ourselves form a part of the physical universe. Whether the impossibility resides within ourselves or in the objects around us is quite immaterial. The important thing is to construct a universe in which a thing can both exist and not exist at the same time. Unfortunately the simplest example is likely to be misunderstood by all except the mathematician and the physicist, but we shall give it for completeness' sake—in a footnote.[1] The reader who can not understand this example will have to apply to some mathematical friend, who will assure him it is easy to see through, after one has studied college mathematics for three or four years. I regret my inability to give a generally intelligible example.

Is the result to be nothing but chaos? No! It is now possible to adopt for the comparison of objects any rules that seem to be convenient or serviceable. It is possible to build a thousand systems of logic, each with its own set of rules for playing the game; to devise new types of syllogism, in which several results may follow from a given set of premises; or to devise still other types in which three or seven premises are essential before a single result can be drawn out.

With certain obvious exceptions, each system of logic can be discussed in terms of the thought forms of any other system, and finally we may hope to attain a knowledge of the actual laws of thought, if there be such; to obtain invariant relations in accordance with which the mind operates whatever be the artificial "laws of nature" which we impose on the objects presented for its consideration. It may be objected that all these logics can be treated in terms of our own system of thought. But it is well to see clearly that they can also be treated in terms of other systems. This gives us an invaluable generality of viewpoint in attacking all kinds of philosophic problems.

Let us give a practical example of the value of these methods, by discussing the existence of God. All the endless rigmarole of proofs of the existence of God would never have been written if the problem had been couched as follows:

In what types of universe, in what systems of logic, with what definitions of existence, with what definitions of the qualities of a Supreme Being, is it possible to prove the existence of that Supreme Being? Does our own system of logic belong to the class of systems in which such a proof is possible?

The generalization to other problems of philosophy is obvious.

It is well to cherish a profound respect for the unknowable. The gifted poet who wrote the book of Job mentions as an attribute of the Divine that

> He calleth the things that are not
> By name as though they were.

[1] Consider a being who dwells in a universe where time is like our space. Let him observe a particle, the space and time coordinates of which remain constant while a quantity analogous to our own time, called quasi-time, continually varies. If the world line of the particle is discontinuous, like a row of dashes – – – – – , then the particle will both exist and not exist at the same time.

TRANSPORTATION

By Professor ARTHUR CLINTON BOGGESS
BALDWIN-WALLACE COLLEGE

How to transport persons, goods and news both quickly and cheaply is an age-old problem which is receiving a progressive, but never complete, solution. After a brief introduction I wish to deal with the present status of transportation in this country with some slight references to conditions in foreign countries.

Our country during the earliest part of its history was narrowly hemmed in between the Atlantic coast line and the Appalachian mountains. Those mountains are not high but any student of physiography or any observant traveler who has passed over the Baltimore and Ohio railway from Pittsburgh to Washington will know that because of its rarely broken sky line the chain was all but impassable for the vehicles of colonial times. So restricted and so poor a country drove its people to the sea for a livelihood. Shipbuilding, fishing, the rum trade, the slave trade and the carrying of commercial freight of other sorts were major occupations. It was not by accident that the United States was so conspicuously successful in naval engagements in the war of 1812.

It was difficult to pass the Appalachians. It was not impossible. Pennsylvania Germans and other northerners moved down the long valleys of the mountain region to what is now West Virginia and western Virginia. The history of sectionalism in this region is a miniature of the history of sectionalism in the United States. Through the Cumberland Gap and a very few other means of difficult and dangerous egress some adventurous spirits filtered into the transmontane region, braving Indians, malaria, loneliness and the multitudinous privations incident to the pioneer.

"Develop transportation or die" might well have been the national slogan of this time. Separatist influences reached the point of imminent danger. The ephemeral state of Transylvania, the Spanish agents, the French agents, were evidences of a discontent that would not be allayed so long as our government either could not or would not provide such means of transportation as would unify its people.

The steamboat was invented none too soon. In but a few years it was followed by the steam railway. The president of the New York Stock Exchange, in an address delivered in September of this year before the New York University Forum, spoke of the early seafaring of our people and then said:

> Suddenly, however, toward the middle of the 19th century, this maritime activity and international outlook vanished. The American merchant marine was slowly abandoned, and the American shipping towns languished, never really to revive. The young men no longer took to the sea. The Stars and Stripes practically vanished, not only from distant oceans, but almost from the Atlantic as well. Abandoning the seaways, the United States turned its face to the western wilderness.
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> This transformation, still so perplexing to Europe in some of its present day consequences, was occasioned by a major historical happening—the successful westward passage of our Appalachian mountain chain by the steam railroad. Almost at a stroke the old coastal settlements along the Atlantic were placed within easy access of what were perhaps the richest agricultural and mineral lands in the world. It is therefore little wonder that America abandoned the seaways for the landways, and that the energy of our people was diverted from roaming the seas to colonizing the wilderness. The whole country suddenly faced the

west, and became immersed in a new and vast internal conquest.

It is well, if we are to grasp the full significance of the last hundred years of American history, that we attempt to visualize the tremendous task undertaken by the early American pathfinders and pioneers. From the summits of the Appalachian mountain chain there stretched away to the westward an enormous valley, extending some 2,000 miles to the Rocky Mountains and the Pacific Coast, and an equivalent distance from the Great Lakes to the Gulf of Mexico. . . . Excepting Russia, the whole continent of Europe could be without difficulty placed inside its tremendous interior reaches. The penetration of this primeval region by the steam railroad at once imposed upon the American people the task of colonizing and bringing under one governmental control this enormous area.

Turnpikes, canals and railways vied with each other for supremacy. Lincoln remarked that people expected to navigate every damp spot. Between the danger of lacking suitable means of transportation and the danger of being bankrupt by attempting to provide such means the choice of our population varied from time to time. Panics, bankruptcies and repudiations delayed progress but could not stop it. By 1916 our railway system had attained its maximum mileage. Some 3,800 miles have been subtracted from the aggregate mileage during the last decade. Additions and abandonments take place each year. The latter exceed the former.

The records of the Interstate Commerce Commission give the reasons for the abandoning of roads. Competition of buses and trucks is insignificant as a cause for abandonment. Chief causes are the exhaustion of mines or timber tracts to which branch lines have been built and the realignment of tracks to avoid circuitous detours and thus shorten the distance between two stations.

Recent new mileage is chiefly for shortening the roads by eliminating curves and detours, for double-tracking and quadruple-tracking and for extending terminal facilities.

That the total freight carried by the railways has increased while the length of line has diminished shows that existing lines are more efficient than formerly. Within a quarter of a century our rail traffic has increased nearly 300 per cent.—from 114 billion ton miles to 338 billion ton miles. The total revenue freight carried by the New York, New Haven and Hartford in 1921 was approximately 22,000,000 tons; in 1925 it was 28,300,000—a gain of nearly 30 per cent. The total number of revenue passengers, exclusive of commuters, in 1921 was 25,200,000, while in 1925 it was only 22,600,000—a loss of 2,600,000. Commuters averaged longer trips and higher rates, however, so that the total passenger revenue increased $1,200,000 over the earlier period.

The Illinois Central System ranks as one of the leading fruit and vegetable carriers in this country and is naturally interested in moving freight as rapidly as possible. Its fruit and vegetable traffic in 1924 amounted to 1,520,794 tons. The principal commodity is bananas, imported through New Orleans, the country's largest banana port. The banana movement continues throughout the year but is heaviest during May, June and July. The movement of deciduous and citrus fruits from the Pacific Coast, approximating the tonnage of bananas from New Orleans, is almost entirely from Omaha to Chicago, with the peak movement in September. Florida citrus fruits move from January to May. Strawberries are brought from the south to the north from February or March to June or July.

The Illinois Central is spending $17,000,000 in building a double-track cutoff from Edgewood, Illinois, to Fulton, Kentucky, a distance of 166 miles. This will save twenty-two miles in the distance between Chicago and New

Orleans. The Central of Georgia Railway (a subsidiary of the Illinois Central System) is reducing grades and curves and cutting down distance on its main line between Birmingham, Alabama, and Columbus, Georgia, at a cost of about $7,000,000.

The Louisville and Nashville is spending $3,000,000 for second track and tunnels near Fort Estill, Kentucky. An aggregate of from $10,000,000 to $12,000,000 is represented in the big work which the Southern Railway System has done and is doing in Tennessee, North Carolina, South Carolina and Georgia.

Electrification of what were originally steam railways has made some progress. The Illinois Central has very recently completed the electrification of its Chicago terminal and it now operates 418 suburban trains a day on this terminal and carries in them an average of 87,000 revenue passengers daily.

Both the Virginian Railway and the Norfolk and Western Railway have electrified some hundreds of miles of their lines, thus greatly increasing their capacity for hauling coal. By the electrification of the Norfolk and Western the average train loading has been increased some 33 per cent., and the average train movements practically the same amount. This means that the track capacity has been very nearly doubled.

On the Chicago, Milwaukee and St. Paul electrification effected a reduction of 22½ per cent. in the number of trains and cut down the time of trains 24½ per cent. Thirty per cent. more tonnage can be handled in 80 per cent. of the time. Electric engines work better in cold weather than in hot weather. When almost all trains in the United States were late during the bitterly cold winter of 1917–18 the trains on the Milwaukee were on time. It is also a great relief to go through long tunnels without needing to close car windows to keep out smoke and gas.

On the Erie railroad between Rochester and Mount Morris the line has been electrified for fourteen years. It has been tied up only once on account of storms and then for only four hours. Steam tie-ups of ten hours to three days had occurred on several occasions.

The electrified terminal makes it possible for great and elegant hotels and businesses of the highest and most exclusive class to exist right alongside a great terminal. There is little noise, no smoke or steam, no hooting of engines, no human suffering and destruction of property from soot and gases.

The regenerative characteristics of electric installation are economical and efficient. The mechanism of the electric engines, when running down grade, is employed to create additional current which is stored for use by engines going in the opposite direction.

Motor bus service is rapidly increasing. One bus line runs from Chicago to Denver, another runs from Denver to San Francisco and another runs from San Francisco to Portland. Probably one can not go from Portland to Denver by bus, but he can go from Portland to Pendleton and from Greeley to Denver, thus shortening the railway journey from Portland to Denver at both ends if he chooses to do so. A bus line operates between Denver and Kansas City. A bus covers the ninety miles between Wanamaker's stores in Philadelphia and New York, respectively, in less than four hours. Well-informed authorities on transportation confidently predict that within a comparatively few years 272,000 additional buses will be added to the 70,000 now in use.

North Carolina and Florida have prospered largely because of the energy of those states in highway building. One writer says:

The improved highway is one thing which, though costing much money, nevertheless, in the end costs nothing to the state, to the community or to the individual user. It is literally something for nothing. Improved roads so greatly lessen the consumption of gasoline per mile and so increase the life of the automobile and tires that the motorist is actually making money when he pays a gasoline tax which enables him to secure good highways.

In North Carolina sleeping car buses are in use.

Probably one of the most romantic developments in motor transportation is that that has taken place in recent years in western Asia. Over the age-old Syrian desert routes American motor cars and even deluxe buses of the latest design are fast replacing the camel caravans and maintaining, in spite of such handicaps as sand storms, floods and marauding Bedouins, a regular service for the transport of passengers and mails. The motor route from India to Beirut, on the Mediterranean, by way of Bagdad, shortens the journey from India to Europe by a fortnight. My friends who come from India on furlough now come from Ur to Canaan by bus. They make better time than Abraham or Jacob, but it is only fair to add that they are less encumbered by children and other live stock than were those worthies.

A regular motor service runs from Bagdad to Teheran, the Persian capital.

The fruit growers in Honduras run their motor trucks on a narrow gauge railroad because improved highways do not exist.

Discussion has already arisen in the United States as to the practicability of subjecting motor bus lines to the control of the Interstate Commerce Commission and making tickets on bus lines, steam railroads and electric lines interchangeable.

The ubiquitous and iniquitous private motor car is too well known to demand much consideration here. For several recent seasons more than one half of the visitors to Yellowstone Park came in their own cars. Many small western towns receive an appreciable and appreciated addition to their incomes from the expenditures of tourists by automobile. Other effects of this means of transportation, together with the movement of goods by truck, are the rapid rise in land values in suburban districts, the delivery of goods by urban stores to ever-widening suburban areas, the growing difficulty of finding urban parking space and the serious problem of preserving at least some of the venturesome pedestrians. Suggested solutions, none of which has yet been tried on a large scale, are sidewalks elevated to the second stories of buildings for pedestrians, the ground level for passenger autos and electric cars and subways for trucks; zoning residential districts, restricting the height of dwellings and requiring community garages to be provided; requiring stores and factories to house, load and unload their own trucks on their own premises; requiring railways to make delivery at the premises of the ultimate consignee.

Postmaster-General New says that the government should leave to private operators the business of carrying the mail through the air. Several contracts have been let to private operators, although there are a number of government operators as well.

A new phase of transportation is the carrying of great quantities of electric energy from its point of production to any place where it is needed. This is called Giant Power. At the biennial meeting of District No. 12 of the United Mine Workers of America, held at Peoria, Illinois, in May, 1924, President Farrington pointed out that under the present method of mining one third of the coal is left in the ground and lost forever. He also said:

It costs nearly as much to haul a ton of coal from southern Illinois to Chicago as it costs to produce the coal.

It costs more to deliver a ton of coal from the car in Chicago to the bin of the consumer than it costs to mine the coal or to haul it from the mine to Chicago.

If the facts were ascertained it might also be found that it costs nearly as much to remove the ashes, cinders and clinkers from the basement of the consumer and dump them into the lake as it costs to mine the ton of coal in the first place. The city of St. Louis, for instance, is paying $2.10 for the removal of a ton of ashes.

It also might be proven that the smoke nuisance caused by the present method of burning coal in large cities is inflicting more damage to buildings, fabrics and health than is represented by the cost of production.

In these few items we have enough waste to equal more than two thirds of the price paid by the consumer. There is, however, a greater waste which is due to the present method of utilizing coal.

To obviate the present wastes the following proposal was made:

(1) The formation of a semi-public corporation in which miners, operators, consumers and the state should be represented.

(2) The establishment of one or more giant power plants on the Ohio and Mississippi rivers for the manufacture of electricity.

(3) A network of power lines to make electricity available to every hamlet and farm house in the state.

(4) The distillation of coal at or near the giant power station, in order to save the by-products of coal which are now wasted.

The benefits anticipated from the plan suggested are:

(1) An increased demand for Illinois coal through (a) The substitution of electric light for kerosene light. (b) The substitution of electric power for gasoline power. (c) The substitution of electric stoves for wood, oil, gasoline and crude oil-burning stoves. (d) The more extensive use of electric labor-saving devices in home and farm, such as washing machines, vacuum cleaners, corn shredders, etc. (e) The illumination of concrete highways. (f) The substitution of artificial anthracite for fuel oil in heating plants.

(2) A marked reduction in the price of light, heat and power at the expense of waste in transportation, selling and delivery.

(3) The stimulation of industry by a steady supply of light, heat and power, at reasonable prices.

(4) The abolition of the smoke nuisance.

(5) Cheaper fertilizer for the reclamation of farm land.

(6) Steady employment of miners.

Taking out by-products, if scientifically done, reduces the energy of coal by from 8 to 15 per cent., varying with the method and the coal used.

The south has made great progress in the use of giant power. As one result cotton manufacturing is shifting from north to south to a marked degree. The south has to-day over one half of the country's cotton mills which are consuming 65 per cent. of all the cotton manufactured in American mills; and are turning out 57 per cent. of the country's cotton goods.

Greater progress is being made in Alabama in the experimental work in connection with the utilization of electric light and power on farms than in any other part of the United States.

This giant power is expected to save coal by using the coal near the mine as has been stated. It is also true that great quantities of electric energy generated by water power can be transported long distances, if necessary, with little loss of power in transportation. This obviates the location of power-consuming factories in the often almost inaccessible vicinity of water power and makes possible the utilization of much water power formerly wasted.

One who keeps informed in regard to changes in transportation must be like Alice in Wonderland, who had to run as fast as ever she could just to keep in the same place. The issue of the *Literary Digest* for October 2, 1926, to mention a periodical not in any sense specializing in the subject, had three diverse major items in regard to various kinds of transportation. The first item stated that with an expenditure of more than ten million dollars and five years of work, during which sixteen million cubic yards of material were moved, the United States Government has converted the old Chesapeake and Delaware to a spacious sea-level canal that will be opened for general use some time in the autumn of the current year and added that at a dinner recently given by the Atlantic Deeper Waterways Association in Washington, General Taylor said: "I look forward to the time when it will be possible for a boat to go from New York to Florida, across Florida, and along the Gulf Coast to Corpus Christi, Texas, without ever going into the ocean."

The second item told of experiments made by Professor Ryan, of Leland Stanford University, on a record-breaking high voltage machine, consisting of six huge transformers, requiring more than two years to build at Pittsfield. More than one hundred miles of wire were required and the total weight is about 270,000 pounds. Its cost was about $500,000. "Looking forward to the time when power must be transmitted for hundreds of miles to meet the demands of the San Francisco territory, the set has been installed by the university so that it may solve well in advance of requirements the problems of high voltage transmission."

The third item told of the achievement of Mr. T. E. Mitten in combining in the Philadelphia Rapid Transit Company ownership and operation of street cars, motor buses, taxicabs, an interurban bus service between Philadelphia and New York City, Wilmington, Valley Forge, Washington and Atlantic City, and an airplane service from Philadelphia to Washington soon to be extended to Norfolk.

The *Classmate* for October 2, 1926, announced that on the seventh of October, at Quincy, Massachusetts, would be celebrated the centennial of the opening to traffic of the first railroad in the United States. This was a genuine and effective railroad, although its cars were drawn by horses.

Other important current projects for transportation are a deep waterway from the Great Lakes to the Atlantic by way of the St. Lawrence and another by way of the Hudson River Valley; a deep waterway from Chicago to the Gulf of Mexico; and various projects for the extension of commercial aviation and for perfecting the radio. The prediction is confidently made that before many years people can sit in their homes and both see and hear the President of the United States deliver his inaugural address and that the phonograph will be so synchronized with the movies that a moving picture house will resemble a theater with actual players present.

In conclusion it is well within the bounds of truth to say that during the 125 years since 1800 transportation facilities have developed to a greater extent than in all history preceding 1800; that the first quarter of the twentieth century saw more of such development than any other period of equal length; and that he who sits by the side of the road and watches the world go by enjoys an increasingly varied and animated spectacle.

THE EFFECT OF CONTACT ON THE SOCIAL ORGANIZATION OF THE AMERICAN INDIAN

By Professor E. E. MUNTZ
NEW YORK UNIVERSITY

The contact of different race groups brings into full prominence the contrast and antagonism of their respective mores and customs. The more widely separated such societies are in culture, the more intense will be the conflict. The codes in themselves furnish a *casus belli*. Each group is imbued with the idea that its ways are the only right ones and is wont to look upon those of the other as ridiculous, perverse and even contemptible. This is especially true when it is a matter of the secondary mores, such as those centering about family customs and religion. Thus we, as members of a civilized society, regard our societal mores to be the best, the only true ones. They are adjustments for us on our present stage of economic and social development. We are used to them, brought up in them and can not, therefore, give an unbiased view of them. Consequently we are shocked and surprised when primitive man sees the ludicrousness of some of our mores and points it out to us. As far as our code is concerned the savage is acting rationally, but with respect to his own he is biased. There is no immediate verification. It is as Professor Keller says: "You can persuade a savage of the inadequacy of his stone hatchet long before he can be made to see that his family system is capable of being superseded by one yielding better satisfaction to his interests."[1] A highly developed and civilized community can not be fashioned at one stroke out of so unpromising material as a primitive race.

The decline and disintegration of the native social system can be attributed, in large measure, to the intolerance of the races of higher culture for the customs and mores of the backward races. This has made itself felt in many ways; for example, the direct prohibition of native customs repulsive to the code of the dominant race and the inculcation of a contempt for the ways of the ancestors in the young of the subject group. Other important reasons for the decline of the native social system are to be found in miscegenation and the selection by the "lower" group of new usages, some of which may be adaptations from the superior race, as a necessary consequence of new life conditions imposed by contact.

Of primitive customs inconsistent with the moral code of western civilization anthropophagy and human sacrifice come in for the most severe condemnation. In one form or another cannibalism has been practiced by large numbers of the American Indians. It was a common custom in the regions of La Plata. Thus Alvar Nuñez assembled all the native subjects of the king at the Ascension and solemnly warned them to give up the eating of human flesh, as that was a sin and an offense in the sight of God. The monks and clergy repeated this warning, and then presents, such as shirts, caps and other things, were presented to the natives whom they hoped to convert to Christianity.[2] The missioners saw the

[1] Keller, A. G., "Societal Evolution," p. 136.

[2] Dominguez, L. L., (tr.), "Conquest of La Plata," by Schmidt and Cabeza de Vaca, (Hakluyt), p. 129.

devil in every faith except their own and could not discern that such native customs as slavery and cannibalism represented early steps toward emerging from the purely savage state.[3] The Botocudos were bitterly hated by the white settlers in Brazil because of their anthropophagous habits, and wars of extermination were launched against them. The Miranhas were also notorious cannibals, though here it seems to have been a matter of blood revenge and superstition; European culture, however, has successfully uprooted the custom.[4] As is well known both Spanish and Portuguese law encouraged the enslavement of cannibal tribes. The notion that the Incas were cannibalistic and had developed human sacrifice to a great degree is denied by Cieza de Leon, who asserts that the origin of such stories was to justify the Spaniards' cruel treatment of the aborigines. Indeed, if his account is to be relied upon, the Incas were responsible for stamping out the practice of cannibalism among all the people with whom they came in contact.[5]

North of Mexico cannibalism was generally a part of war custom and was principally based upon the belief that bravery and other desirable characteristics of an enemy would pass through actual ingestion of a part of his body into that of the consumer. The idea of eating any human being other than a brave enemy was repulsive to most Indians.[6] Cannibalism is also found as an expression of affection for members of the "in-group," and frequently serves for purposes of sorcery. Human sacrifices and sacramental cannibalism exist among the Bella-coola Indians of British America. Children of the poor were purchased from their parents for sacrificial purposes; the souls of the sacrificed were supposed to go to live in the sun and become birds. When the English government prohibited this practice the priests dug up corpses and ate them. Several were thus poisoned.[7] It is the vital connection with religious mores and the supernatural which makes these customs of primitive races most difficult to eradicate.

Many times contact with the white race has caused the substitution of new customs appertaining to the higher culture for ancient usages which were quite essential for the welfare of the aborigines. For instance, the wearing of clothing in the *igloo* has proven most harmful to the Eskimo:

> The custom—an adaptation whose abrogation has resulted in sickness—was to strip upon entering the *igloo*, the temperature of which, in the absence of ventilation, is high. Thus does the skin get a chance to exhale after being inclosed in fur garments whose pores have been filled up to exclude cold. But the crowded *igloo* allows of little or no privacy. Hence the naturalness of nakedness and the absence of shame; hence also a lack of chastity and decency as judged from the standpoint of codes formed under other conditions.[8]

Letourneau sees the disintegration of the native social system pictured in the

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[3] Burton, R. F., "The Captivity of Hans Stade," (Hakluyt), p. 146, note.

[4] Von Martius, C. P., "Ethnographie u. Sprachenkunde Amerika's," I, 316 and 538.

[5] Markham, C. R., (tr.), "Second Part of the Chronicle of Peru," by Cieza de Leon, pp. 79–80.

[6] Handbook of the American Indians, B.A.E., Bulletin 30, pt. I, pp. 200–1. Note: That there are exceptions to the above statement is evident from the explanation of a Miranha chief as to why his people practiced cannibalism. "You whites," said he, "will not eat crocodiles or apes, although they taste well. If you did not have so many pigs and crabs you would eat crocodiles and apes, for hunger hurts. When I have killed an enemy it is better to eat him than to let him go to waste. Big game is rare because it does not lay eggs like turtles. The bad thing is not being eaten, but death, if I am slain, whether our tribal enemy eats me or not. I know of no game which tastes better than men. You whites are really too dainty." Spix and Martius, "Brasilien," 1?49—quoted in Sumner, W. G., "Folkways," p. 331.

[7] Sumner, W. G., "Folkways," p. 333.

[8] Keller, A. G., "Societal Evolution," p. 269.

disappearance of guest friendship and the acquisition of capital. For example, in the Northwest Territories of Canada there are now rich tents and poor tents, and the occupants of the latter may die of hunger without causing uneasiness to their richer tribesmen. The savages will no longer render any assistance without pay. A missionary who had given many years of his life to helping the Indians was wounded in the foot; his parishioners passed him by without offering assistance, until he called to one, who responded, "How much will you give me if I carry you?"[9]

One of the characteristic phases of Indian life was their great number of associations, fraternities and secret societies, as well as public councils and conferences. These things evolved from actual social needs and each organization, game dance, feast or custom filled some social need. "Civilization swept down upon them because they differed from our code; dances were broken up, councils and ceremonies were forbidden, and social customs frowned upon because they were 'barbarous.' "[10] In the spring of 1909 a memorial was unanimously adopted at a gathering of the secretaries of the several mission boards maintaining stations in the Indian field to the effect that "inasmuch as the sun dance and certain other Indian dances are essentially immoral in their tendency, resolved, that the Department of Indian Affairs be requested to take more urgent steps to enforce their prohibition."[11] It seems impossible for the Indian's critics to understand that the dance is not a mere amusement for him as it is with us, but that it is as replete with religious emotion as a stirring religious revival in the white settlements. If left alone there is no question that in the course of evolution the dance will disappear of its own accord, for already the Indian has lost much of the zest he used to feel for the dance, and his faith in its efficiency as a religious rite is badly shaken if not utterly destroyed.[12] This is certainly indicated at the present time by the commercializing of the Snake Dance and various religious rites by the Hopi Indians and other tribes. The magical fraternities and secret societies are also disappearing as their social need wanes.[13]

In spite of the fact that changed life conditions produced by contact with the white race has left meaningless many old social customs, they continue as survivals in the daily life of the Indian. For instance, the Peruvian Indians, even though accepting Christianity, place coca leaves in the mouth of a corpse and hang round its neck a little bag containing various seeds for its plantations in the next world. The aborigines maintain some of the old Inca customs under modern guise; periods of sowing and reaping are celebrated with merrymaking and intoxication; dances, at which the participants' dress is similar to the mode worn by the ancient Peruvians in

[9] Letourneau, Ch., "L'evolution du commerce," pp. 186–7.

[10] Parker, A. C., "The Social Elements of the Indian Problem," in *American Journal of Sociology*, (1916–7), XXII, 258.

[11] The commissioner, Mr. F. E. Leupp, points out how little the reverend gentlemen actually knew in regard to the Indian dances: "I obtained a list of the gentlemen who had voted on this proposition, and wrote a separate letter to each one, asking (1) in what respect the measures I had already taken had in his judgment fallen short, and (2) what measures he would advise my taking for the future, to the end of breaking up dancing among the Indians. The answers were interesting as a study in constructive criticism. Every voter for the memorial assured me (1) that he did not know what methods I was already pursuing, and (2) that he knew so little personally about the subject that he was unable to offer any advice."

[12] Leupp, F. E., "The Indian and his Problem," pp. 248–51.

[13] Webster, H., "Primitive Secret Societies," p. 124.

the Raymí (monthly dances), survive. These are frowned upon as relics of an inferior culture in the larger towns where the mestizo population predominates. One very interesting custom, recalling those of the Australians and other primitive peoples, of performing what the mores forbid, survives on Christmas day when the "negritos" appear. These are Indians with their faces concealed by hideous negro masks. They perform the dances of the Guinea negroes and imitate the attitudes and language of a race which they hold in abhorrence. The "negritos" parade the streets for three days and nights, entering houses and demanding chicha and brandy.[14] Many of the ancient secret societies of the Aymara Indians survive, apparently more for social than for religious purposes, although they strongly partake of a religious nature.[15]

It is, however, with respect to marriage and the family that the most far-reaching social consequences of contact with a superior culture are to be seen. In the arts and industries of native life there was a well-defined sex division of labor, and so firmly fixed was this that the Jesuits in Canada were quite unable to alter it to any appreciable extent. The missionaries were laughed at and called women when they got their own firewood or performed chores which among the Indians were allotted to the women.[16] The savages resented the interference of the whites in their domestic affairs. In Baird's relation there is an account of how the native husbands were accustomed to beat their wives for the slightest cause. One Indian, rebuked by a Frenchman for this, answered angrily: "How now, have you nothing to do but to see into my house, every time I strike my dog?"[17] The status of woman was slightly improved, however, by the efforts of the priests, especially among those peoples who were made sedentary or partially so. Marriage and the home were made more permanent; conditions of motherhood were improved, and abortion, infanticide and child sacrifice were condemned and suppressed by the priests.[18] Contact with the whites has caused a gradual decline of female infanticide among the Eskimo about Bering Strait.[19] In addition to the influence of the white man an increase in the food supply might be given as a collateral cause.

Polygamy, alien to the civilized code, never fails to excite the greatest antagonism on the part of the whites. It is most frequently a subject for regulation; likewise the looseness of the marriage contract among the natives. The Jesuits held that the best way to render marriage permanent was to establish the European custom of a dowry for the bride, reasoning that the husband would not so readily leave a wife who brought some property with her. The dowry was furnished by friends in France. Divorce was not allowed in the communities where the Jesuits had control. The Indian attitude on this question is expressed by Father Le Caron:[20]

> One of the greatest obstacles to their conversion is that most of them have several wives, and that they change them when they like, not understanding that it is possible to submit to the indissolubility of marriage. "Just see," they tell us, "you have no sense. My wife does not agree with me and I can not agree with her. She will be better suited with such a one, who does not get on with his wife. Why,

[14] Von Tschudi, J. J., "Travels in Peru," pp. 337, 259–63.

[15] Bingham, H., "Inca Land," pp. 197–8.

[16] Lee, F. E., "The Influence of the Jesuits on the Social Organization of the North American Indians," p. 76–7.

[17] Baird's Relation, "The Jesuit Relations and Allied Documents," III, 103.

[18] Lee, F. E., "The Influence of the Jesuits . . . ," p. 3.

[19] Nelson, E. W., "The Eskimo about Bering Strait," in 18th Annual Report, B.A.E., pt. I, (1896–7), p. 289–90.

[20] Le Clerq, Father C., (tr. J. G. Shea), "First Establishment of the Faith in New France," I, 221.

then, do you wish us four to be unhappy the rest of our days?

The priestly objection to polygamy frequently led to very perplexing situations. At St. Joseph polygamy was done away with among converts. But to those adherents possessing more than one wife the mandates, "Thou shalt not kill," and "Thou shalt not have more than one wife," together with the ecclesiastical prohibition of divorce, presented a very intricate problem. The missioners decided that such polygamous marriages could not be dissolved, and that a man, for instance, having three wives might be held as an adherent until two of his wives should die, whereupon conversion could take place.[21] It is interesting to note that contact with the whites indirectly increased polygamy among the Omaha. The stimulation of the hunt and commerce weakened the old village life, created new standards of wealth and lowered the status of woman. Men took to polygamy in order to get female labor to work on the pelts.[22]

One of the inevitable consequences of contact with the culture races is miscegenation. In Brazil the scanty European population took to the ways of the natives in its attempt to conform to an environment which it could not control; the adoption of the native mode of living facilitated an early fusion of races and several varieties of half-breeds came soon to be distinguished, for there was but little reason for emigration other than deportation for crime; consequently but few white women were to be found in the colony.[23] In the Amazon region to-day most Portuguese engaged in rubber gathering or trade take Indian wives. These women are of inestimable worth to their husbands, for without their knowledge of the native dialects and their influence over their own people it would be quite impossible for the ruling class to maintain the condition of Indian vassalage that exists.[24]

The objects of emigration to the Spanish colonies—adventure, conquest, etc.—virtually excluded women. The privilege of migration was strictly withheld from single women, and it was difficult to get a wife who had been left behind. Consequently there was a prevailing absence of Spanish women and mixed unions inevitably followed.[25] The official attitude was in favor of intermarriage. The lewdness of the Spaniards who cohabited with the most beautiful native women of Hispaniola gave offense to the Franciscans. Accordingly, Governor Ovando issued orders that the Spaniards must either part with their Indian concubines or marry them. Fear of losing their control over the Indians, which was considerably strengthened through these female connections, induced many of the Spaniards to marry.[26] Racial amalgamation early became a settled policy in Mexico under the rule of king and church. Charles V encouraged the legal marriage of Spaniards and Indian women, doubtless with the idea of ultimately making the population white; the church especially favored race-crossing in order to hasten the true Christianization of the people. Later, when Spanish women began to go to the colonies their union with Indian aristocrats was sanctioned by the king and urged by the church.[27] Miscegenation was brought about among some of the indomitable

[21] Lee, F. E., "The Influence of the Jesuits," p. 215.

[22] Fletcher, A. C., and La Flesche, F., in 27th Annual Report, B.A.E. (1905–6), p. 614.

[23] Koster, Henry, "Travels in Brazil," II, 167.

[24] Rice, A. H., "Notes on the Rio Negro (Amazonas)" in *Royal Geographic Journal*, Oct., 1918, p. 213.

[25] Moses, B., "The Establishment of Spanish Rule in America," pp. 58–9. Bourne, E. G., "Spain in America, 1450–1580," pp. 265–6.

[26] Kerr, Robt., "Gen. History and Collection of Voyages and Travels," III, 387–8.

[27] Thompson, W., "The People of Mexico," p. 29.

native groups in Chili by the natives carrying off white women whom they captured in raids made upon the Spanish settlements.[28]

Although there appears but little reluctance on the part of most native races to alliances with the whites, the Tarahumares of Mexico form a notable exception. Until very recently light-colored children were not liked and half-caste babies were frequently left in the woods to perish or given away to be adopted by the Mexicans. Mothers even yet anoint their little ones and leave them in the sun that they may get dark. The general opinion is that half-castes turn out to be bad people and "some day will be fighting at the drinking feasts." In the border districts, however, intermarriage with the Mexicans is noted with increasing frequency.[29]

North of Mexico the French intermarried to the greatest extent with the aborigines. French colonists were prone to see in the Indian a fellow human being; to recognize the native's pride and prejudices, and finally to win his confidence by respecting his institutions and often sharing in his ceremonies.[30] The French priests would fain have adopted the Indian as a countryman and even proposed that a number of young Frenchmen should settle among the Hurons and marry their daughters in solemn form. The aborigines were gratified with so pleasing an overture. "But what is the use," they asked, "of so much ceremony? If the Frenchmen want our women, they are welcome to come and take them whenever they please [referring to the traders] as they always used to do."[31]

The various fur and trading companies established for traffic in the regions west of the Great Lakes and in the Hudson Bay country were particularly influential in altering the social life of the natives. They brought into their habitat a class of men, French, English and Scotch, who were not adverse to taking native wives. This was favored by the great fur companies as the best means of exploiting the country in a material way.

The Cree and Chippewa have perhaps furnished the most mixed bloods, followed by the Sioux, Ottawa, Menominee and tribes about the Great Lakes. Some intermixture of captive white blood is noticeable among the Apache, Comanche, Kiowa and other raiding tribes along the Texas and Mexican borders. The Pueblos have never favored intermarriage with the whites. The Five Civilized Tribes of Oklahoma—Cherokee, Choctaw, Chickasaw, Creeks and Seminole—have a large element of white blood, dating back in some cases to British and French traders before the Revolution. The Cherokees, in particular, have encouraged fusion, for under the former laws of the nation any one who could prove the smallest proportion of Cherokee blood was rated as Cherokee, including many of one sixteenth, one thirty-second or less of Indian blood. The Cherokees have drawn the color line very strictly with reference to Negroes, but others have intermarried freely. In 1905 there were over twenty thousand adopted Negroes in the territory belonging to the Five Civilized Tribes. Many of these Negroes are descendants of slaves formerly owned by the Indian tribes. The Pamunkoy, Chickahominy, Narragansett and Marshpee remnants have much Negro blood, and it is probable that many of the broken coast tribes have been completely absorbed into the Negro race.[32]

[28] Ulloa, Don Antoine de, "Voyage de l'Amerique," I, 65–6.

[29] Lumholz, C., "Unknown Mexico," I, 417–8.

[30] Handbook of the American Indians, B.A.E., Bull. 30, pt. I, 475.

[31] Parkman, F., "The Jesuits in North America," I, 226.

[32] Handbook of the American Indians, Bull. 30, pt. I, 914.

Considerable race-mixture occurred in the northwest through Russian traders. The whites, either by force or agreement, compelled the Aleuts to hunt for them and to give hostages, generally women and children. The Aleuts were thereupon given traps and sent forth to hunt for the season, while the Russians lived in indolent repose at the village, basking in the smiles of the wives and daughters and using them as they saw fit. In spite of the apparent cruelty of the Russians they were much preferred to other Europeans, because they assimilated more readily with the aborigines than did the other traders. They lived together with and in the manner of the natives.[33] In view of the hostage system and the character of the Russian trader it is questionable if his presence had anything more than a destructive influence upon native social life and customs. Wholesale miscegenation has taken place in Greenland, and it is difficult to find a pure-blooded Eskimo on the west coast. "The native women prefer the worst Dane to the best Greenlander and the half-breeds are the more eligible for their strain of white blood; illicit relations with white men are rather a glory than a disgrace." Race mixture is favored by the Danish government, but the mongrels resulting from these alliances do not appear noticeably superior to the native stock.[34] Among the Point Barrow Eskimo prostitution is carried to a shameless extent with the sailors of the whaling fleet by many women and is even considered a laudable thing by the husbands and fathers, who are always willing to receive the price of their wives' or daughters' frailty.[35] The purity of the race has steadily declined.

That miscegenation has had a profound effect upon the social life of the American Indian is not open to doubt. The half-breed, finding that the native race from whence he has sprung is undervalued or despised by his foreign parent, seeks to alienate himself from it and hastens to abjure its customs and prejudices and all community of feeling with those who belong to it. On the other hand, he is unable to adopt the ideas and assume the pretensions of Europeans and is constrained to take an intermediate station. In this position, uncontrolled by the usages or the habits of thought peculiar to either race, unable to identify himself with the one and unwilling to align himself with the other, he becomes, as it were, negative in the scale of society, and remains a conspicuous example of one of the many ills which are entailed upon uncivilized nations by contact with races of superior culture.[36] The half-breeds of northwest Canada class themselves as the equals of the whites and look patronizingly at the Indians.[37] Humboldt was anything but enthusiastic over the results of the mixture of races in Mexico; the product is described as lazy, carefree and considerably below the mulatto in activity.[38] It may be accepted as a general rule that wherever Spain held sway in America the immigrant Spaniard held in contempt the creoles, and especially the mestizos, who formed the industrial element in the colonies; the mixed races felt superior to the native or Negro stocks from which they had sprung, and the Negro, with his superior strength and the favor of his master, treated the Indians with insolence and scorn. The different shades of color were classified

[33] Bancroft, H. H., "History of the Pacific States," XXVIII, 285–6, 250–1, 339.

[34] Keller, A. G., "Colonization," p. 515.

[35] Murdoch, J., "The Point Barrow Eskimo," in 9th Annual Report, B.A.E., (1887–8), pp. 419–20.

[36] Howison, J., "Views of the Colonies," II, 336.

[37] Reid, A. P., "Half-breed Races of N. W. Canada," in J.A.I., IV, 48.

[38] Humboldt, A., de, "Neuvelle-Espagne," II, 37–8.

most minutely not only by the force of custom but also by law. Each caste envied those above and despised those below.[29]

Thus among primitive peoples whose customs were sanctioned and upheld by centuries of tradition came representatives of the white race with customs and teachings completely at variance with Indian usage. The very impact from the clash of two so widely different cultures could not fail to materially affect the social life of the "lower" races. The Indian's first adjustments were in the economic field, but it was not long before changes were produced in native societal life as a consequence of imitating the ways of the whites, the selection of new mores in accord with new conditions, the prohibition of native customs inconsistent with the code of the European, the education of the young and the growth of new social groups with the fusion of the European, African and Indian, possessing nothing but contempt for the ways of the aborigines.

[29] Keller, A. G., "Colonization," p. 220; Leroy-Beaulieu, P., "De la colonisation . . .," I, 11.

GAPS IN THE MONGOLIAN LIFE RECORD

By Professor WILLIAM K. GREGORY

AMERICAN MUSEUM OF NATURAL HISTORY

PART II

THE Third Asiatic Expedition has discovered in the rocks of Mongolia a splendid record of earth history and an equally wonderful record of the life of past ages. But these records themselves are far from being the whole story; in fact, their great value is that they supply certain parts of the story that are missing elsewhere and that they agree so closely with what has already been worked out in other parts of the world. If the story of earth history and the history of past life as generally accepted by scientists were merely the first crude attempts to formulate the complexities of nature it would be found that after a great new world was discovered the older theories would collapse under the mass of new facts placed upon them. But in this case the newly discovered geological formations fit admirably into the geological column based on the record built up of comparative studies on all the great land masses of the world, while the new fossils cause only a widening of our outlook and no revolutionary upset of the existing classification, so that the sciences of geography, geology and paleontology have stood well the pragmatic tests imposed by the discovery of thousands of new facts.

In order to show how the Mongolian records of past life fit into the story as a whole, let us review briefly the general outline of the evolution of the vertebrate animals as it has been deciphered before the Third Asiatic Expedition began its explorations.

It is not yet generally agreed how the vertebrates, or backboned animals, arose, that is, from what group of invertebrates they started upon the career that culminates in the evolution of man. Mongolia, like other land masses, has hitherto failed to yield the decisive evidence. The oldest fish-like vertebrates so far known, which date back to the Ordovician of Colorado, already had obtained a whole series of "basic patents," or fundamental mechanical arrangements, which they transmitted to their remote descendants, the fishes and land-living vertebrates of later ages. They and their descendants of the Silurian and Devonian ages had already solved the problem of capturing food and energy from the environment with the aid of a complex apparatus for locomotion of the vertebrate type. For this object their bodies were built on streamline forms, they moved by the contraction of a series of > -shaped muscle segments placed on either side of a stiff elastic rod, the notochord, their sense organs and brains were already built up into a head of vertebrate type and they had pouches from the throat called gills for extracting oxygen from the water.

By early Paleozoic times the primitive fishes had already adapted themselves for life in the inland waters of the great land masses. Some of them that lived in foul waters gradually took to gulping air from above the surface of the water and storing it in a special sack from the throat which eventually became a lung. Certain of these air-breathing fishes developed stout paddles, a pair behind the throat and another about the middle of the body, and these paddles correspond precisely to the two pairs of limbs that even man himself still possesses. Some of the air-breathing fishes with stout paddles struggled out of the

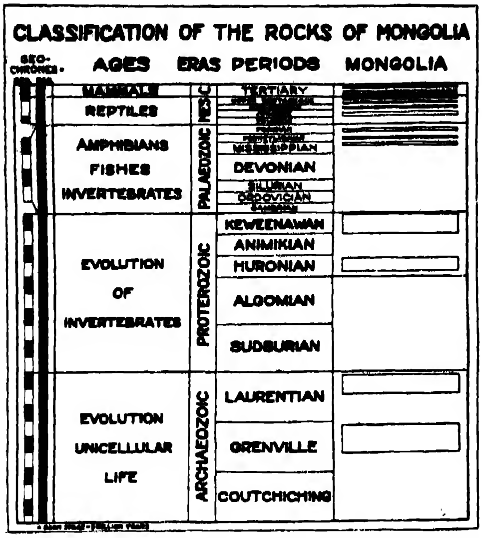


FIG. 1. GEOLOGICAL SEQUENCE OF THE ROCKS OF MONGOLIA

THE STANDARD GEOLOGICAL DIVISIONS ARE SHOWN IN THE MIDDLE COLUMN, MONGOLIAN FORMATIONS IN THE RIGHT-HAND COLUMN (AFTER MORRIS).

pools in the swamps where they lived and thus gave rise to the swarming amphibians of the oldest coal-measures. The eggs and young of these animals still passed through a fish-like, water-living stage of development, like the tadpoles of frogs and salamanders, but the adults had the form of four-legged animals capable of crawling on the ground. Very early in the coal-measures time some of these early amphibians succeeded in rearing their young completely on land, the fish-like stage being passed through within the egg, and thus the great class of reptiles arose. By the time of the Permian or close of the Paleozoic era the reptiles in turn had begun to divide into many branches, some of which later gave rise to the dinosaurs, marine reptiles, flying reptiles and mammal-like reptiles of the "Age of Reptiles" (Mesozoic era).

The Age of Reptiles in Mongolia

The rocks of the oldrock floor of the desert of Gobi are either of marine origin or are so thoroughly modified by mashing, heating and other processes

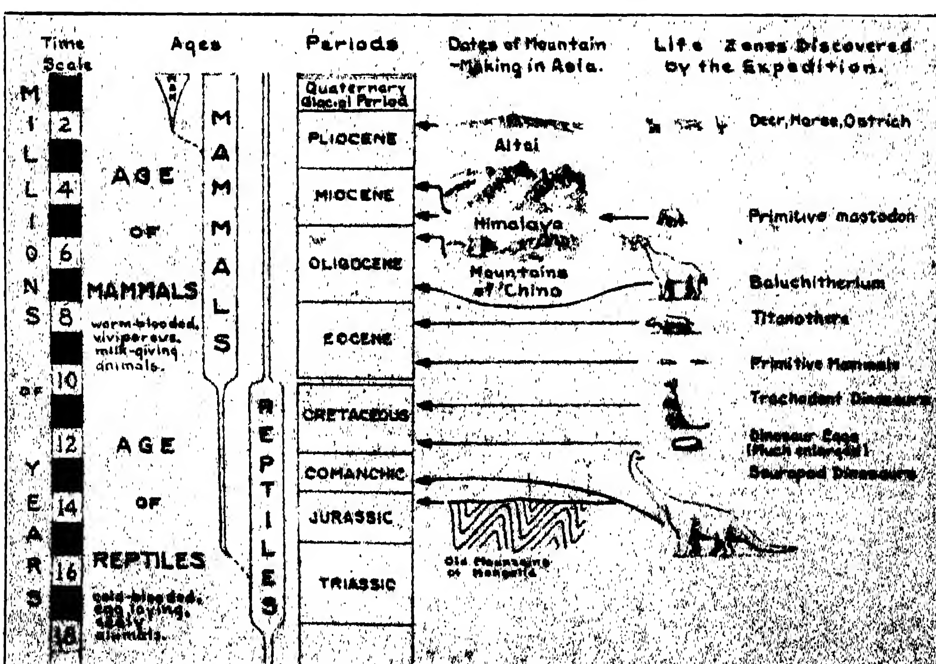


FIG. 2. SEQUENCE OF LIFE IN MONGOLIA (AFTER MORRIS).

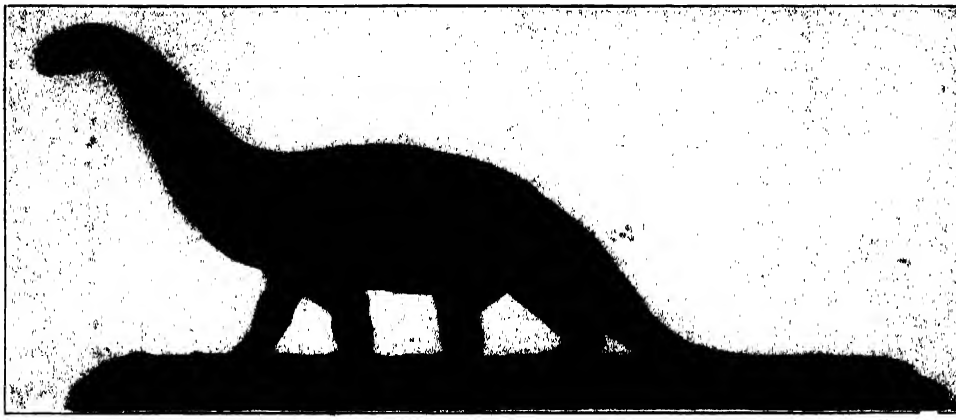
that they have so far yielded no part of the story thus briefly outlined. But above the oldrock floor the sedimentary strata are all of continental type and the record of vertebrate life begins with the Cretaceous or last epoch of the Mesozoic, or Age of Reptiles. Although by this time the closing chapter of the history of the dinosaurs had been reached, Mongolia supplies some important pages in it.

The American Museum fossil hunters in Mongolia are constantly reminded of scenes familiar to them in the great fossil-bearing basins of the Rocky Mountains and Great Plains. We can imagine then the thrill that Mr. Walter Granger experienced when at the Red Mesa of the Oshih Basin in Western Mongolia he picked up a fossil tooth which he instantly recognized as establishing the former presence in Mongolia of gigantic amphibious dinosaurs akin to the *Brontosaurus* which he himself had excavated many years ago in Wyoming, the sixty-foot skeleton of which is now mounted in the American Museum in New York. And how exciting it was to find a similar tooth about two hundred yards away, then several badly weathered limb bones, and finally three miles away and on a somewhat higher level, a couple of gigantic vertebrae with several long ribs. And how tantalizing to Mr. Granger and his small party that the expedition must move on and that the ribs and vertebrae were too badly weathered and disintegrated to be worth excavating and that there was not another scrap visible in the whole basin. But even the three teeth that were brought home to the American Museum afforded some valuable information to Professor Henry Fairfield Osborn, who described them. Somewhat spoon-shaped or spatulate, they differed only in minute details of form from those of the lumbering giant named *Camarasaurus* from Colorado, Utah and Wyoming, and appeared in fact to represent a new genus of the same family. On the other hand, they differed considerably from the long pencil-like teeth of the slender-limbed, swan-necked *Diplodocus*, the companion of *Camarasaurus* and *Brontosaurus* in North America.

Here then was a new and astonishing link between Mongolia and our own west. Did the giant long-necked amphibious dinosaurs originate in Mongolia and then spread by the Behring straits route to northwestern America, or did they first develop their peculiar habits and body form perhaps in Europe, where their representatives are known in equally old and much older formations, and then spread to Asia, North America, South America, India and Australia?

The ponderous *Asiatosaurus*, as Professor Osborn named this huge earth-shaking beast, was not allowed to wax fat in the land of plenty without having a relentless enemy to prevent him from possessing the earth. Ferocious flesh-eating dinosaurs, alert bipeds with huge jaws and saw-edged teeth, like those of *Megalosaurus* of England or of the *Allosaurus* of Wyoming, left a couple of their teeth in the same beds with those of the *Asiatosaurus*. That these great flesh-eating dinosaurs did prey upon the amphibious dinosaurs or sauropods is indicated by the fact that in Wyoming some sauropod vertebrae were found with tooth marks on them which seem to have been made by the teeth of *Allosaurus*, the contemporary flesh-eating dinosaur. Here then was another link between Mongolia and Wyoming, the peculiar association of sauropods and carnivorous dinosaurs.

In the same Red Mesa the bright eyes of Wong, Mr. Andrews' Mongol chauffeur, discovered one of the most valuable fossil skeletons of the entire expedition. This was afterward named the parrot-beaked dinosaur (*Psittacosaurus*) and was described by Professor Osborn. Although apparently adult the total length from snout to tail-tip was only about four feet, four inches. The skeleton is now exhibited in the museum in



Photograph by American Museum of Natural History

FIG. 3. *CAMARASAURUS SUPREMUS*
AN AMERICAN RELATIVE OF *Asiatosaurus* (AFTER OSBORN).

approximately the same position in which it lay in the rock; but by means of a series of careful drawings of the individual bones it was possible to make an accurate reconstruction of the animal in a running position (Fig. 4). That it ran upon its hind legs is suggested not only by their much greater length as compared with the fore limbs but especially by the detailed anatomical characters of the pelvis, which is of the bird-like, bipedal type.

Small, bipedal, beaked dinosaurs have been found in Wyoming in the same formation with the great sauropods and carnivorous dinosaurs; but the Mongolian *Psittocosaurus* differs from its American and European relatives in the parrot-like form of the beak. *Psittacosaurus* was evidently herbivorous like his American and European relatives, since the cheek teeth formed a cutting and grinding surface suitable for shearing tough vegetable tissue. The jaws and skull were very stout and the jaw muscles very powerful, in order to operate effectively the piercing beak and the shearing cheek teeth. Possibly the reptile fed on the somewhat pineapple-like fruits of the cycads.

Interesting mechanical adaptations are seen in the jaws of *Psittacosaurus* (Fig. 9, A) and of all other beaked dinosaurs, the upper and lower jaws acting somewhat like nutcrackers, since they are hinged both above and below. The beak acts like a pair of spring shears, with the power applied between the resistance and the fulcrum. The joint between the lower jaw and the supporting pillar of the upper jaw is below the level of the cheek teeth, whereas in more primitive reptiles this joint is in line with the cheek teeth. This arrangement is carried to an extreme in the later beaked dinosaurs. It not only gives an increased vertical space for the jaw muscles but makes it possible to increase the height of the cheek teeth, thus lengthening their period of usefulness, besides putting the lower teeth in an advantageous position to sweep across the upper teeth in an oblique or nearly vertical plane, in the cutting of tough food.

The pelvis of this interesting reptile shows a peculiar combination of characters; for while its prepubis is short, simple and not expanded or plate-like, its backwardly directed true pubis already shows the first stage in the secondary reduction or degeneration of the pubis, which culminates in its almost complete loss in the horned dinosaurs or ceratopsians. The opposite ischia are produced into a channel, the upper sur-

face of which has been called the "egg chute."

Egg-layers and Egg-stealers

This brings us directly to the subject of dinosaur eggs, perhaps the most famous discovery of the Third Asiatic Expedition. Andrews has already told the story of the discovery of these eggs, but why do we feel so sure that they are the eggs of dinosaurs rather than of other reptiles or birds? First, these eggs have been pronounced by several experts after careful examination to be different from the eggs of all known crocodiles, turtles, lizards and birds. Second, the eggs are very abundant in a formation from which seventy-odd fossil skulls or skeletons of a certain beaked dinosaur (*Protoceratops*) have been taken and in which other animals are quite rare. Third, the same formation has yielded a whole series of growth stages of this same dinosaur *Protoceratops*, some of the little skeletons being almost small enough to be newly hatched from the eggs. Fourth, some of the eggs contain partly ossified skeletons of the young animals and the appearance of the bone is quite like that of the smaller skeletons of *Protoceratops*. Fifth, the microscopic structure of these eggshells, as reported by Professor Van Straelen, of Belgium, while strikingly different in details from those of nearly all known eggs, living or fossil, is fundamentally similar to that of the supposed dinosaur eggs from Rognac in southern France. Hence it may be taken as sufficiently proved that the "dinosaur eggs" are truly eggs of dinosaurs and further that they belong to the beaked dinosaur known as *Protoceratops*.

Now as to the remarkable animals that laid the eggs. The first discovered skull of the reptile now called *Protoceratops* was found on the Kwei-hwa-ting trail, east of the Artsa Bogdo range, Mongolia. When sent home to the laboratory of the museum in New York the skull was still buried in the rock and no one knew what it was or had yet seen more than a small part of it. As the rock was gradually cleared off and the beak-like snout came into view our wonder increased, for at that time no other small reptile was known with a face like this one. When the lower jaw came into

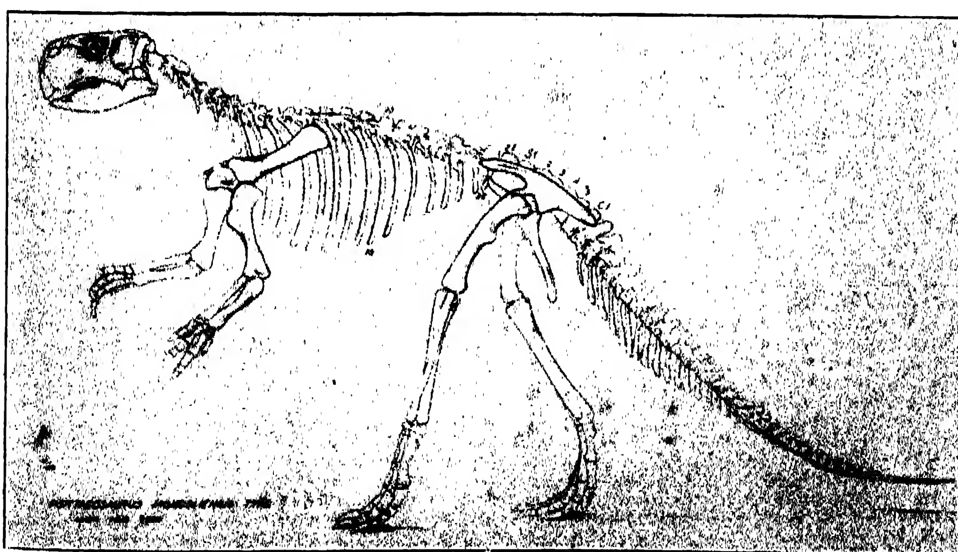


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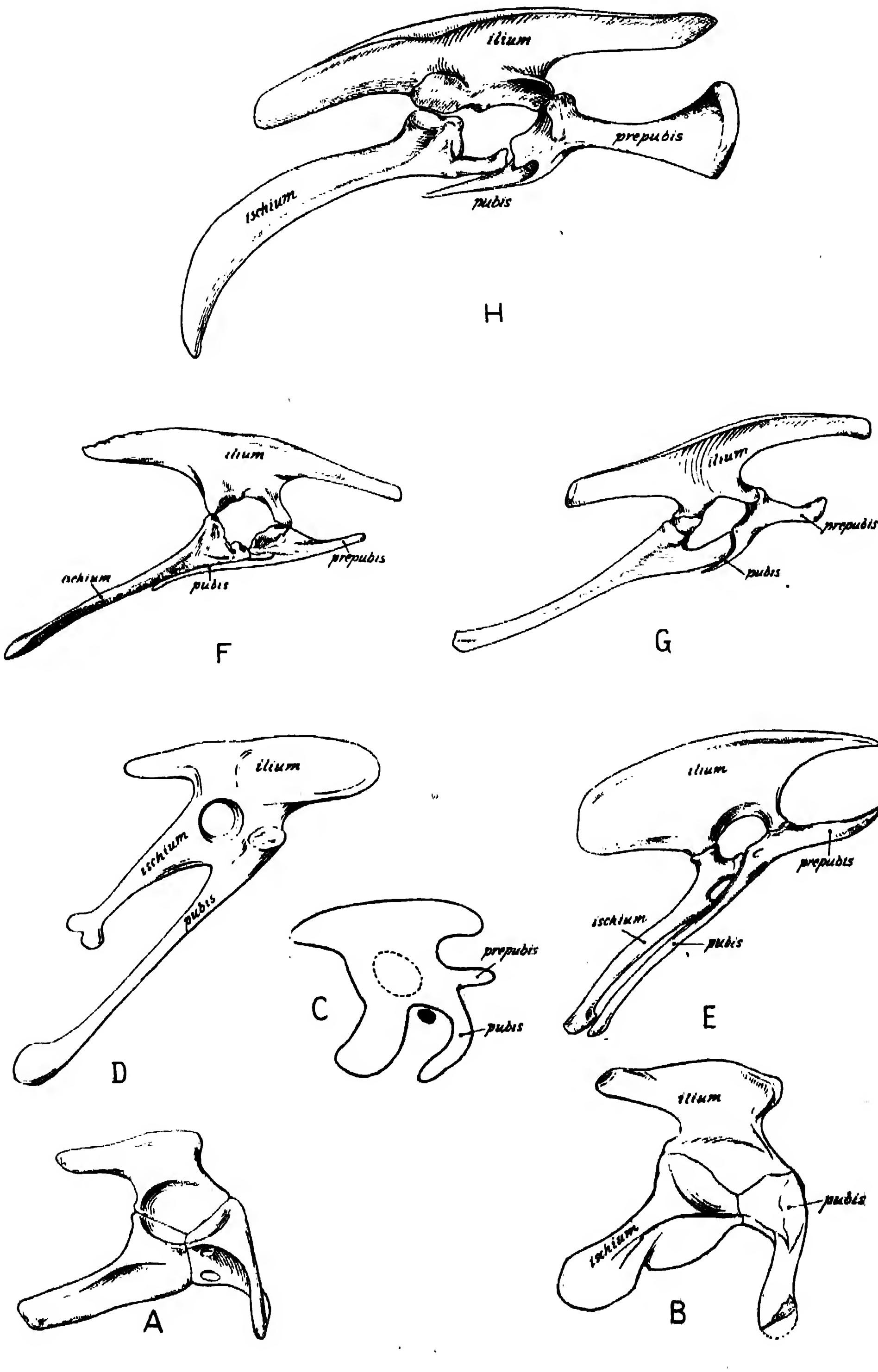
FIG. 4. SKELETON OF *PSITTACOSAURUS MONGOLIENSIS* OSBORN (AFTER OSBORN). RESTORED PARTS IN DOTTED LINES.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view we saw that it possessed a "predentary" bone at the front and gradually we realized that we were looking for the first time at an Asiatic representative, and probably an ancestor, of the great horned dinosaurs or ceratopsians, which up to that time were known from numerous skulls and a few skeletons from the Cretaceous, chiefly of Wyoming, Montana and Alberta. But our Mongolian specimen was a very small form with a skull about six inches long and no bony horns or outgrowths above the nose or eyes, while some of its gigantic American relatives had skulls six feet in length with great horns or bony outgrowths above the nose and eyes. Moreover, the back part of our specimen was broken and we did not know whether or not it possessed a bony "frill" or shield, extending upward, backward and outward over the neck. Nevertheless, the detailed evidence of relationship to the ceratopsian dinosaurs was so unmistakable that Mr. Granger and the present writer did not hesitate to baptize the little Mongolian skull as "*Protoceratops andrewsi*," the first of the horned dinosaur group, the species being named in honor of the leader who had opened up this great new world of past life.

During the years 1923 and 1925, the Third Asiatic Expedition made a great collection of the remains of these dinosaurs, including some seventy-odd skulls and skeletons, many of which have since been worked out of the rock. In the second paper on *Protoceratops*, the present writer, in collaboration with Dr. Mook, showed how *Protoceratops* completely realizes the implications of Dollo's inference that even the great horned dinosaurs were secondarily quadrupedal in posture, that is, that they had been derived from bipedal ancestors. For *Protoceratops*, while probably spending most of its time on all fours like the later ceratopsians, and while unmistakably foreshadowing the latter in many features, at the same time differs from them in retaining a series of peculiar characters in its skeleton which it has apparently inherited from bipedal ancestors that in many ways resembled *Psittacosaurus*. For example, its hind limbs are much longer and larger than its fore limbs, the hind foot being narrow and much longer than the fore foot, almost as it is in the bipedal *Psittacosaurus*, while in the more advanced quadrupedal ceratopsians of later times the hind foot was much broader and little, if any, longer than the fore foot. Again, the tibia or shin bone is longer than the femur or thigh bone as in running, beaked dinosaurs. The pelvis is more advanced than that of *Psittacosaurus* in the greater lengthening of the ilium, further reduction of the backwardly directed pubis, initial expansion of the prepubic process and slight downward curvature of the elongate rod-like ischia. These and other modifications of the pelvis indicate that *Protoceratops* at least spent more time supported on all

FIG. 5. EVOLUTION OF THE PELVIS IN BIRD-LIKE DINOSAURS AND BIRDS

RIGHT SIDE, FRONT END OF THE PELVIS TOWARD RIGHT. A. PRIMITIVE PELVIS OF SMALL LIZARD-LIKE REPTILE (*Euparkeria capensis* BROOM) FROM THE TRIASSIC OF SOUTH AFRICA. B. FOSSIL REPTILE (*Erythrosuchus*, AFTER BROOM) FROM THE TRIASSIC OF SOUTH AFRICA. THE PUBIS IS BEGINNING TO GROW DOWNWARD AND SLIGHTLY BACKWARD. C. EMBRYO BIRD (*Apteryx*, AFTER PARKER). THE PUBIS IS GROWING DOWNWARD AND BACKWARD IN FRONT OF THE OBTURATOR NERVE (OVAL SPOT). A PREPUBIS IS PRESENT. D. *Archaeopteryx*, JURASSIC BIRD (AFTER ABEL). THE PUBIS IS DIRECTED BACKWARD. THE PREPUBIS IS REPRESENTED BY A LOW HUMP IN FRONT OF THE SOCKET FOR THE FEMUR. E. SMALL BIRD-LIKE DINOSAUR (*Laosaurus consors* MARSH) SHOWING PUBIS PARALLEL TO ISCHIUM. FROM THE JURASSIC OF WYOMING. F. *Protiguanodon mongoliense* OSBORN. THE PUBIS IS REDUCED TO A SLENDER ROD. FROM THE LOWER CRETACEOUS OF MONGOLIA. G. *Protoceratops andrewsi*. THE PUBIS IS REDUCED TO A VESTIGE. FROM THE CRETACEOUS OF MONGOLIA. H. *Triceratops prorsus*. THE PREPUBIS IS GREATLY EXPANDED. FROM THE UPPER CRETACEOUS OF NORTH AMERICA.

Photograph by American Museum of Natural History

FIG. 6. DINOSAUR NEST

THIRTEEN EGGS IN BLOCK AS MOUNTED IN THE AMERICAN MUSEUM OF NATURAL HISTORY.

four legs and less time running on its hind legs than did its less modified neighbor *Psittacosaurus*, while the enormous size of the head and jaws in proportion to the size of the backbone and thorax, as well as other marked specializations for the eating of herbivorous food, all give added reasons for the increased use of the quadrupedal posture and the gradual abandonment of bipedal running. Thus the *Protoceratops* was now getting big enough to stand and confront a hungry enemy, doubtless threatening him with his fierce beak, and no longer needed to turn and flee away on his hind legs.

The skull of *Protoceratops* shows very pronounced modifications in the direction of the later ceratopsians. In the very earliest reptiles the whole surface of the skull behind the eyes was formed by a continuous shell of bone which covered over the jaw muscles. But by the time of the oldest dinosaurs this formerly continuous temporal region had become perforated by two prominent openings called the upper and lower temporal fossae. Between these openings were left strengthened tracts or arches, an upper middle pair, the parietal crest, between the upper temporal openings, a second pair, the postorbital arches, above and behind the eyes, and a lower pair, the jugal arches, just above the lower jaw. In such relatively primitive beaked dinosaurs as *Psittacosaurus* the jaw muscles were of moderate size and the temporal arches did not extend much behind the joint between the upper and lower jaws. But in *Protoceratops* the jaws and jaw muscles had become very large and in so doing had pushed their supporting arches upward, backward and outward, so that the skull is prolonged in the rear into a great spreading crest or frill. Formerly it

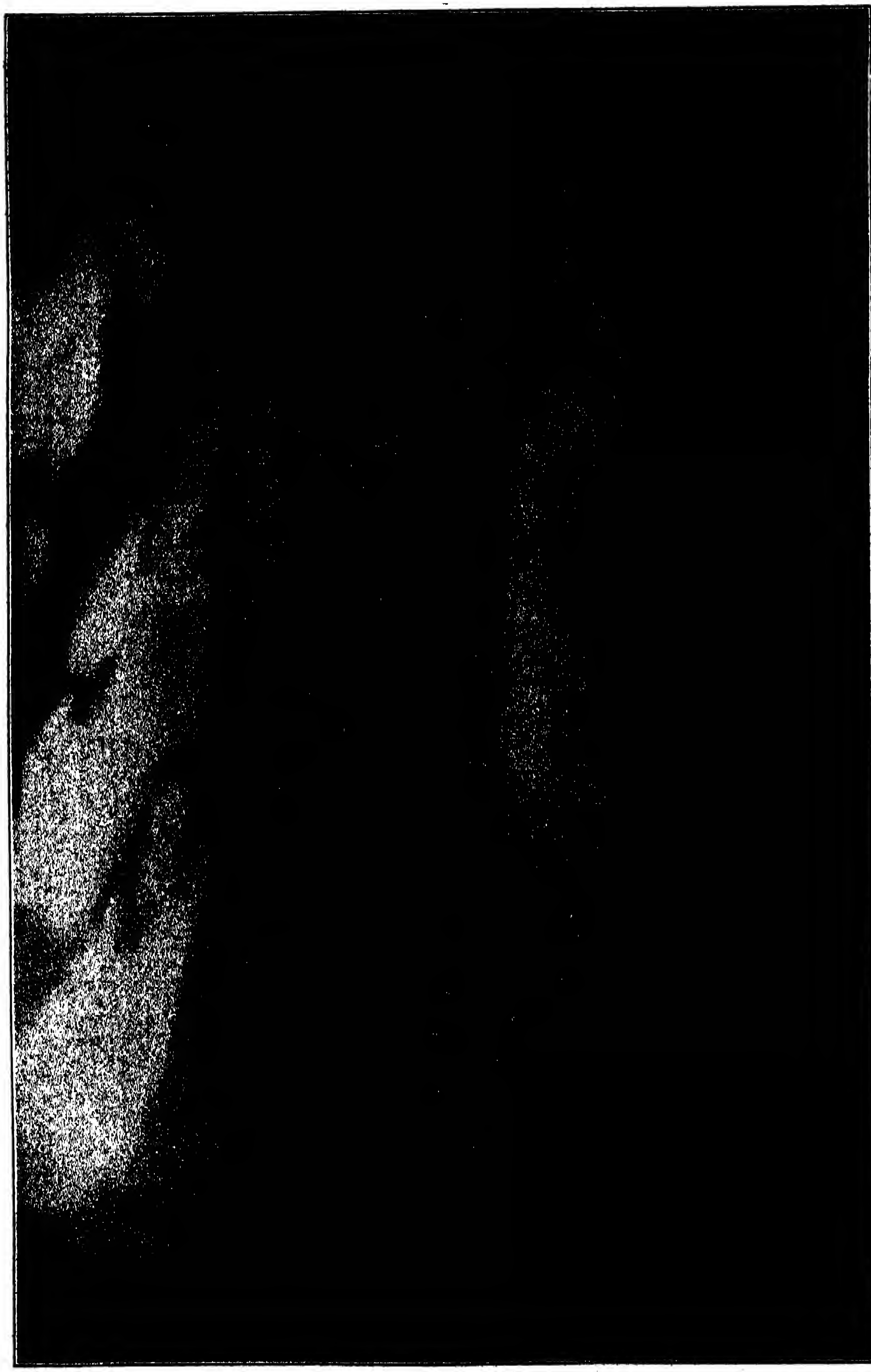
was believed that this crest or frill, which is even further developed in the later ceratopsian dinosaurs, was evolved for the protection of the neck, but the construction of this region in Protoceratops plainly indicates that it functioned primarily as a scaffolding for greatly enlarged jaw muscles.

Are we to conclude then that the horned dinosaurs (ceratopsians) acquired their special characters in Mongolia and then spread via Manchuria and the Behring Straits or Aleutian Islands route into Alaska and thence down to the Rocky Mountain region? We can not safely affirm this on the evidence afforded by any one type of animals, but we can affirm that there must have been some means of migration either in one direction or another. Some years ago Mr. Barnum Brown, of the American Museum of Natural History of New York, discovered the fragmentary skeleton of a small horned dinosaur in the Edmonton Cretaceous, Alberta, which he clearly saw was distinct from the larger horned dinosaur and to which he gave the name *Leptoceratops*. It is now evident that *Leptoceratops* is quite nearly related to Protoceratops and that it represents a little-changed descendant of the latter in North America at a time when the typical ceratopsians had reached the summit of their period of specialization. Some paleontologists will undoubtedly take this fact to mean that the larger ceratopsians were not descended from *Protoceratops* but from some undiscovered stem form. However this may turn out, it is safe to predict that even if *Protoceratops* be not the direct ancestor of the great horned dinosaurs, it was at least rather closely related to that ancestor and shows us a stage in which the ceratopsians had just acquired secondary quadrupedal habits

Photograph by American Museum of Natural History

FIG. 7. *PROTOCERATOPS ANDREWSI*, TYPE SKULL

OBLIQUE SIDE VIEW. ABOUT TWO THIRDS NATURAL SIZE.



Photograph by American Museum of Natural History

FIG. 8. *PROTOCERATOPS* AND YOUNG

RESTORATION BY E. R. FULDA.

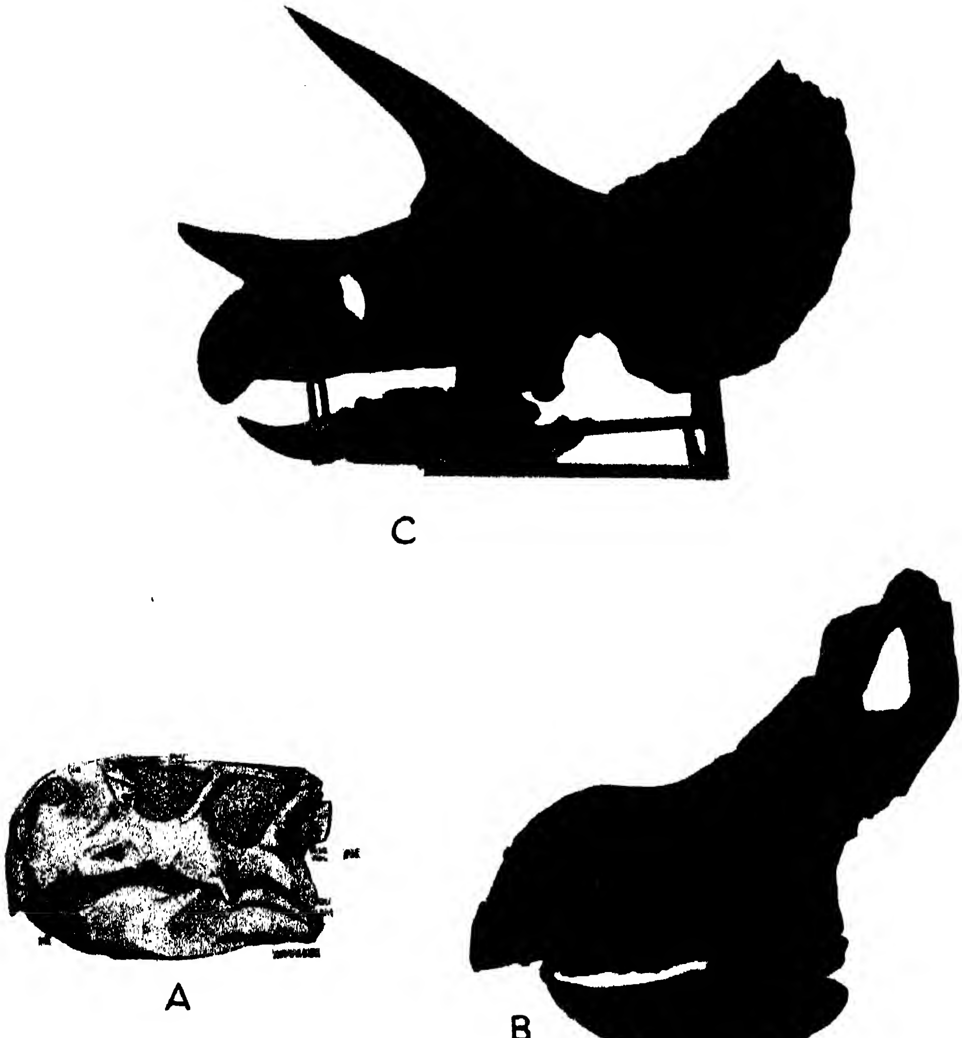


FIG. 9. THREE STRUCTURAL STAGES

NOT IN DIRECT LINE OF SUCCESSION, ILLUSTRATING EVOLUTION OF THE FRILL AND OF HORNS IN THE FRILLED DINOSAURS. A. *Psittacosaurus mongoliensis* (AFTER OSBORN). SKULL WITHOUT CREST. FROM THE CRETACEOUS OF MONGOLIA. B. *Protoceratops andrewsi* GRANGER AND GREGORY. SKULL WITH OCCIPITAL CREST. NO HORNS. C. *Triceratops prorsus* MARSH. SKULL WITH HUGE OCCIPITAL CREST AND BONY "HORNS" ABOVE EYES AND NOSE.

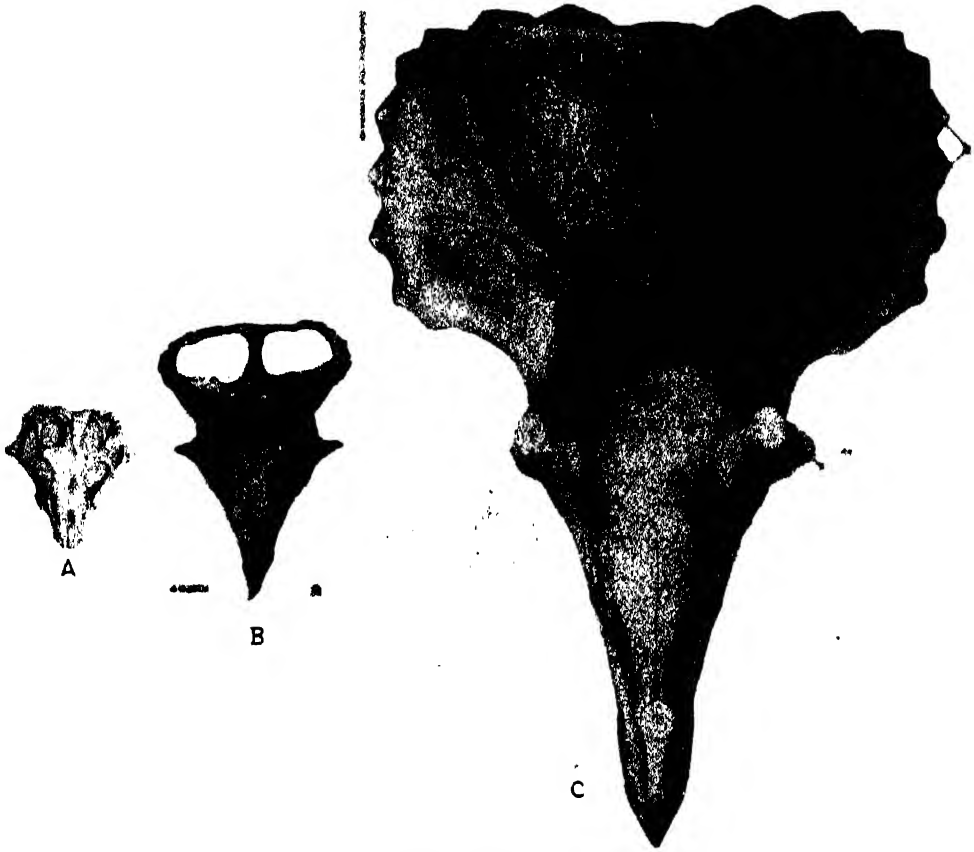


FIG. 10. THREE STRUCTURAL STAGES IN THE EVOLUTION OF THE OCCIPITAL CREST IN DINOSAURS. A. *Psittacosaurus mongoliensis* (AFTER OSBORN). CREST INCIPIENT. B. *Protoceratops andrewsi.* CREST WELL DEVELOPED. C. *Triceratops ceratus* MARSH. CREST ENORMOUS.

and an enlarged bony scaffolding for the jaw muscles.

Several other kinds of small dinosaurs inhabited the Gobi region in those far-off days of *Protoceratops* and left their skeletons to puzzle the paleontologists that found them. One small light-limbed dinosaur skeleton was found buried in sand in close proximity to a nest of *Protoceratops* eggs and it was suggested that this dinosaur had been overtaken by a sandstorm in the very act of robbing the nest, but this idea has been gravely questioned by the geologists. Professor Osborn therefore named it *Oviraptor philoceratops,* signifying "egg seizer, fond of *Protoceratops* eggs," but at the same time warns us that this name may entirely mislead us as to the true feeding habits, which are difficult to infer with certainty. The skull is very peculiar, being a toothless derivative of an originally carnivorous type, with the stout jaws much shortened in front of the large eyes. Possibly the jaws were sheathed in a horny covering or beak. The animal, however, did not belong to the "beaked dinosaur group," the skull being built upon a widely different plan, fundamentally similar to that of the small bird-like dinosaurs of North America. The animal was a swift-running

biped with a very long second finger on the hand, again recalling that of the American bird-like dinosaur *Struthiomimus* and raising one of the still unsolved problems as to the habits of these strangely bird-like dinosaurs.

Another very small dinosaur has a very lightly built but well braced skull about seven inches long with long jaws armed with sharp cutting teeth. The claw of the first finger of its hand was very large and sharp, like a falcon's claw, and the animal was doubtless a swift-running biped. It was named *Velociraptor mongoliensis* by Professor Osborn. In another small dinosaur, named by Professor Osborn *Saurornithordes mongoliensis*, the skull was so bird-like in appearance, except for the presence of teeth, that when found in the field it was thought to be a bird skull. These dinosaurs are far too late in geological time to be the true ancestors of birds, but with their almost wing-like hands and lightly built skulls they merely parallel the actual ancestors of birds.

Another reptile that was a neighbor of the *Protoceratops* was a small crocodilian described by Dr. Mook, which apparently represents a new genus and species, possibly even a new family of this interesting order of reptiles. The crocodile order is the only existing one that is at all nearly related to the dinosaurs. Thus the popular idea that dinosaurs are giant lizards is true only in the widest sense.

At Iren Dabasu in western Mongolia the explorers discovered the incomplete skeleton of a beaked dinosaur of the duck-billed group of North America. This skeleton is now being studied by Mr. Barnum Brown, of the American Museum of Natural History. In some respects it is related to some of the crested dinosaurs of the duck-billed group. In other respects it is peculiar.

Thus all the dinosaur groups known from the Cretaceous of North America have representatives also in Mongolia, but none of the Mongolian forms appear to belong to exactly the same species as any hitherto-known dinosaurs of Europe or North America. It is too early to attempt a final appraisal of the faunal relations of Mongolia, but at least we may be sure that its extinct reptilian faunae had some vital connection of relationship and derivation with those of Europe and North America.

THE PROGRESS OF SCIENCE

THE PHILADELPHIA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

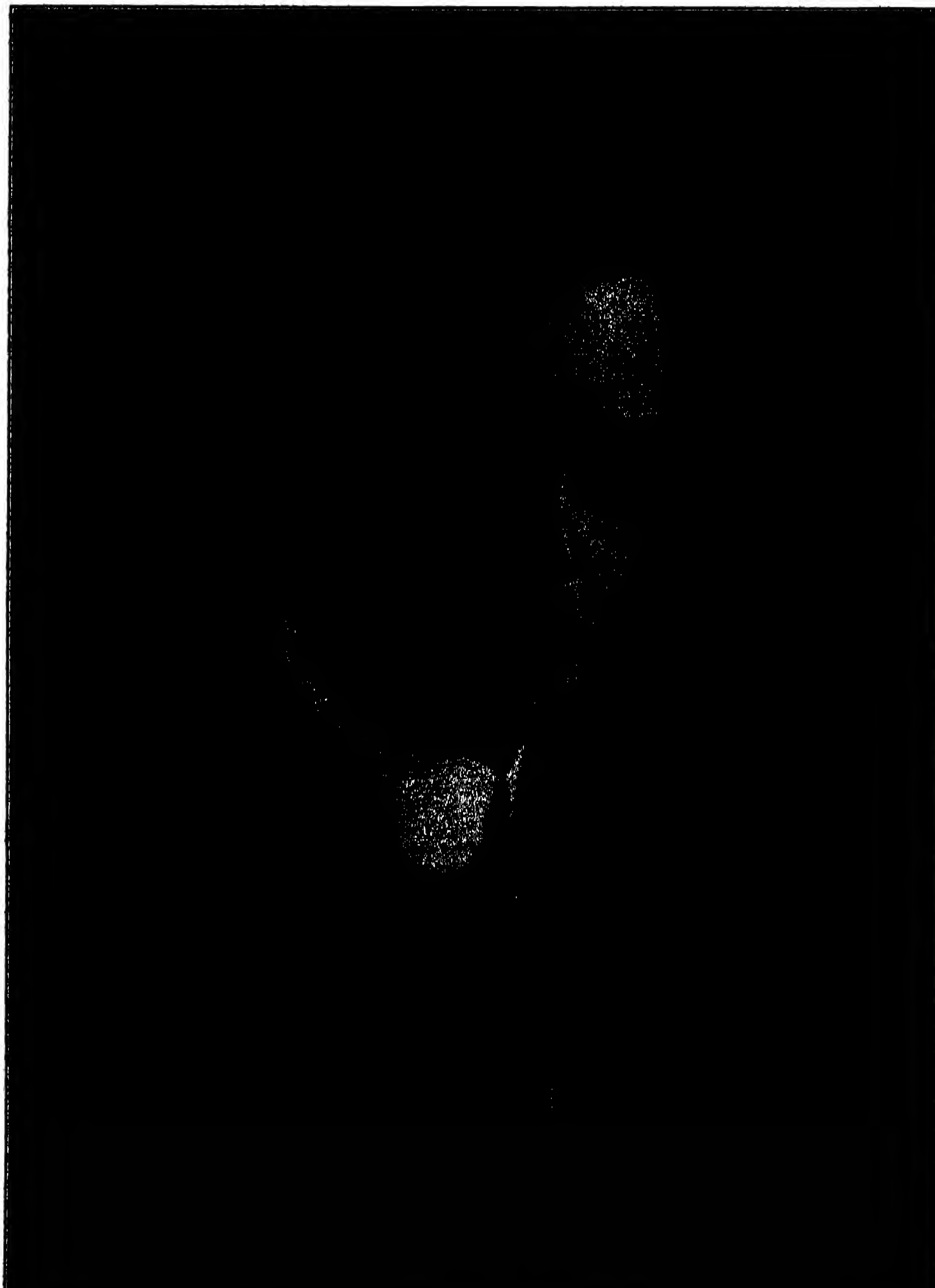
EDITED BY DR. E. E. SLOSSON
Science Service, Washington, D. C.

THE American Association for the Advancement of Science held its first meeting in Philadelphia in 1848. The fifth meeting in that city, held during convocation week—usually the week in which New Year's Day falls—was one of the most successful and largest in the history of the association. Some forty scientific societies met in affiliation with the association; some 1,500 papers were included on the scientific programs, and the total attendance was probably considerably in excess of five thousand.

The meeting was held under the presidency of Dr. L. H. Bailey, eminent systematic botanist and editor of our most useful books of reference on cultivated plants and rural life. Dr. Bailey was president of the International Congress of Plant Sciences, held last August in Ithaca, N. Y., and he holds the presidency of the Botanical Society of America. The retiring president of the association is this year Dr. Michael I. Pupin, of Columbia University, known to all scientific men for his research and inventions in electro-physics and to a wide public for his autobiography, "From Immigrant to Inventor." Dr. Pupin delivered the address of the retiring president on the evening of Monday, December 27, at the opening of the meeting, the subject being "Fifty Years' Progress in Electrical Communication."

Numerous other general sessions of the association and meetings of general interest were held during the week. The annual lecture before the Society of the Sigma Xi was given by Mr. Herbert Hoover, secretary of commerce, who spoke on "The Nation and Science." Dr. George F. H. Nuttall, professor of biology in the University of Cambridge, gave an illustrated lecture on the University of Cambridge, and Dr. J. H. Myres, professor of classical archeology at the University of Oxford, general secretary of the British Association, lectured on "Geographic Conditions of Ancient Greek Culture." Among the numerous sessions of general interest was one on research in colleges and professional schools arranged by the Committee of One Hundred; one on the relation of science to education, under the auspices of the American Association's committee on this subject; one on hydrobiology; one on quantitative methods in biology; one on growth in health and disease; one on the biological aspects of medical problems, and one on law enforcement.

Dr. A. A. Noyes was elected president of the association, there being two other living chemists who have held this honor, Dr. Ira Remsen, president emeritus of the Johns Hopkins University, and Dr. Theodore W. Richards, professor of chemistry at Harvard University. Dr. Noyes has been director of the Gates Chemical Laboratory at the California Institute of Technology since 1920. Previous to that time he had been director of the research laboratory of physical chemistry at the Massachusetts In-



PROFESSOR ARTHUR A. NOYES

ELECTED PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AT THE PHILADELPHIA MEETING.

DR. LIBERTY HYDE BAILEY AND DR. MICHAEL I. PUPIN

DR. BAILEY (WHO STANDS ON THE LEFT) PRESIDED OVER THE PHILADELPHIA MEETING OF THE AMERICAN ASSOCIATION; THE ADDRESS OF THE RETIRING PRESIDENT WAS GIVEN BY DR. PUPIN.

stitute of Technology, where he had also been for two years acting president.

Dr. Noyes was born at Newburyport, Mass., in 1866. His education began at the Massachusetts Institute of Technology, where he received his bachelor's degree in 1886 and his master's degree a year later. He went to Germany for his Ph.D., which he received at Leipzig in 1890. He holds honorary degrees from the University of Maine, Clark University, the University of Pittsburgh, Harvard University and Yale University.

Dr. Noyes was long a member of the executive committee of the American Association; he represents the National Academy of Sciences upon the board of trustees of Science Service; he was president of the American Chemical Society in 1904 and received its Willard Gibbs medal in 1915. The chemical research which has given Dr. Noyes distinction covers a wide field, including the rare elements, thermodynamic chemistry, the ionic theory and class reactions for the identification of organic compounds.

"The day of genius in the garret has passed, if it ever existed," said Secretary Herbert Hoover in addressing the honorary scientific society Sigma Xi. Now-a-days, as he pointed out, "discovery must be builded upon a vast background of scientific knowledge, of liberal equipment. It is stifled where there is lack of staff to do the routine, and valuable time must be devoted to tending the baby or peeling potatoes or teaching your and my boys. The greatest discoveries of the future will be the product of organized research free from the calamity of such distraction. Yet the whole sum we have available to support pure science research is less than ten million a year with probably less than four thousand men engaged in it." But in the application of science to industry we are spending probably two hundred million with perhaps thirty thousand men engaged. Yet fundamental research in pure science is the basis of its applications. "Faraday in the pursuit of fundamental law discovered that energy could be transformed into electricity through induction. It remained for Edison, Thomson, Balle, Siemens and many score of others to bring forth the great line of inventions which applied this discovery from dynamo to electric light, the electric railway, the telegraph, telephone and a thousand other uses which have brought such blessings to all humanity. It was Hertz who made the fundamental discovery that electric waves may traverse the ether. It was Marconi and De Forest who transformed this discovery into the radio industry. It was Becquerel who discovered the radio activity of certain substances and Professor and Madame Curie who discovered and isolated radium. It was Dr. Kelly who applied these discoveries to the healing art and to industrial service. It was Perkins who discovered the colors in coal tar by-products. It was German industrial chemists who made the inventions which developed our modern dye industry. It was Pasteur who discovered that by the use of aniline dyes he could secure differentiation in colors of different cells, and this led to the discovery of bacilli and germs, and it was Koch and Ehrlich who developed from this fundamental discovery the treatment of disease by antitoxins."

"Much of the peculiar quality of Greek civilization depends upon the interaction of the mountains and the sea; much also depends on the composition and structure of the mountain masses themselves." This was the main theme of the public address given by Dr. J. L. Myres, general secretary of the British Association for the Advancement of Science. Ancient Greek culture developed in a region of half-submerged mountains forming an exceptionally complex type of scenery of islands, bays and promon-

tories. The Greeks had marble, copper, iron and gold, but almost no coal, and this permanent shortage of power in the Greek world has its reflection in Greek civilization in the constant shortage of labor and the prevalence of slavery. Grains were precarious and the only secure crops were from deep-root trees like the vine and olive. "Under these conditions industrial activity was possible locally with the two main industries—textiles based on the wool of the pastures and hardware of various kinds derived from the mineral resources of the old crystalline rocks. In times of danger from continental land powers the Aegean settlements shrank to the sea-front of all promontories and in-shore islands. On the other hand, in time of danger from sea-pirates, the settlements withdrew from the sea on to high ground wherever possible. When sea piracy is eventually reduced in extent under new control of organized sea powers elsewhere, for example by Rome and by France and England in modern times, the hill villages spread once more down to the sea coast."

Mathematics lies at the basis of all the other sciences and a science is regarded as becoming most scientific when it can be treated by mathematical methods. Astronomy and physics reached the mathematical stage first, chemistry is rapidly following suit and recently biology and psychology are making use of mathematics. On account of the fundamental importance of mathematics any advances in this field are welcomed by investigators in every field of research. Consequently it is not surprising that the thousand-dollar prize offered for a notable contribution to the sessions of the American Association for the Advancement of Science has been awarded this year to Professor G. D. Birkhoff, of Harvard University, for his presidential address before the American Mathematical Society entitled "A Mathematical Critique of Some Physical Theories." Only professional mathematicians will understand its significance, so all that can be done here is to show what the paper is about and why it is considered important by experts. Geometry was developed into a perfect logical system by the Greeks and until the nineteenth century was taught exclusively as the last work in this science. But recently it has been found possible to develop other systems of geometry, equally consistent within themselves. This raised the question whether the Euclidean geometry or some of its newer rivals, the non-Euclidean geometries, best fitted the world as it is. When Einstein pointed out that the non-Euclidean geometry gave a better explanation of other physical phenomena, mathematicians plunged into the new field with greater zest. Professor Birkhoff has taken a step beyond Einstein. He accepts the four dimensional view of space and time embodied in the theory of relativity as "reasonably correct qualitatively" but points out that no way has yet been found to account for all the lines of the spectrum of light, which are ascribed to the frequency of vibration of various parts of the atom. The atom was formerly regarded as simple, but is now-a-days regarded as composed of positive and negative electrical particles, called protons and electrons, the unlike bodies attracting and the like bodies repelling each other. But Professor Birkhoff proposes the use of a new type of elastic body and the "new assumption that the electrical forces between the charges on one and the same proton or electron are attractive instead of repulsive." The laws of space and time in the atomic domain seem irreconcilable with the known statistical laws that can be directly verified, but he hoped that "the mathematicians would develop various types of mathematical universes which might subsequently be of aid to the physicist."

The universe may be infinite in extent,

Dr. Heber D. Curtis, director of the Allegheny Observatory of the University of Pittsburgh, pointed out in his address. Once it was believed, he said, that if the stars were uniformly distributed throughout space without end, the night sky would appear continuously as bright as the sun, and that somewhere in this universe speeds of the bodies would be infinite, presumably an impossibility. The theory of relativity supplied one answer to this by suggesting that the universe is a limited amount of space, yet without any definite boundary, similar to the surface of a sphere, where a particle could travel indefinitely without ever coming to an end, but would also be in a definitely limited amount of space. According to Dr. Curtis, however, the universe could be infinite, and if the stars were not distributed uniformly, but in groups, the difficulties of a bright night sky, and of infinite speeds, would not occur. This is the way the universe is actually constructed, he said, for our groups of stars, or galaxy, is a watch-shaped cluster, and outside its boundaries, scattered throughout space, are millions of spiral nebulae, which have been shown to be other galaxies of stars.

Now that the atomic theory has been applied to light the next question is to determine the size of the individual atoms or quanta of which a beam of light is thought to be composed. No one has yet found out how small they are, but E. O. Lawrence and J. W. Beams working at Yale have found how big they are not. They have invented a shutter of such almost incredible quickness as to cut a ray of light into segments or pulses of only three inches in length, although light travels at the rate of 186,000 miles a second. Yet each of these flashes lasting less than a ten billionth of a second is sufficient to register its effect upon their extremely sensitive photo-electric cell. So the unit of light, whatever it is, must be shorter than that.

A new investigation of a radio death-force was reported to the American Association for the Advancement of Science by Professor R. W. Wood, of the Johns Hopkins University, and A. L. Loomis, of Tuxedo, N. Y. They arranged two metal plates a couple of inches apart, and connected them with an electrical oscillator like the ones used in radio sending sets but much smaller. This drives into the plates an intense electric current, alternating at the rate of approximately one hundred million times a second, and giving rise to extremely short radio waves, about three meters long. A mouse placed between the plates, though not touching either one of them, was killed by the intense electromagnetic field. It died in about half a minute, and its blood was found to be coagulated in its veins. A test tube containing several insects was next tried. The insects were likewise quickly killed, and their bodies became dry and brittle. Professor Wood stated that the experiments were begun only recently and that the near future is likely to bring some startling results, but he pointed out emphatically that a devastating death-ray to kill at great distances is not to be looked for from this apparatus.

The direct measurement of the inherent vitality of any kind of living being is the novel and ambitious undertaking of Professor Raymond Pearl, director of the Johns Hopkins Institute for Biological Research. He has applied his method to two widely different types of creatures, one in the animal and the other in the vegetable kingdom, the fruit-fly and the canteloup. He found the same distribution of individual differences in the duration of life of the insects deprived of food and in the sprouting of the melon seeds also without external nutrition.

The sexes are distinguished throughout the animal and vegetable kingdom,

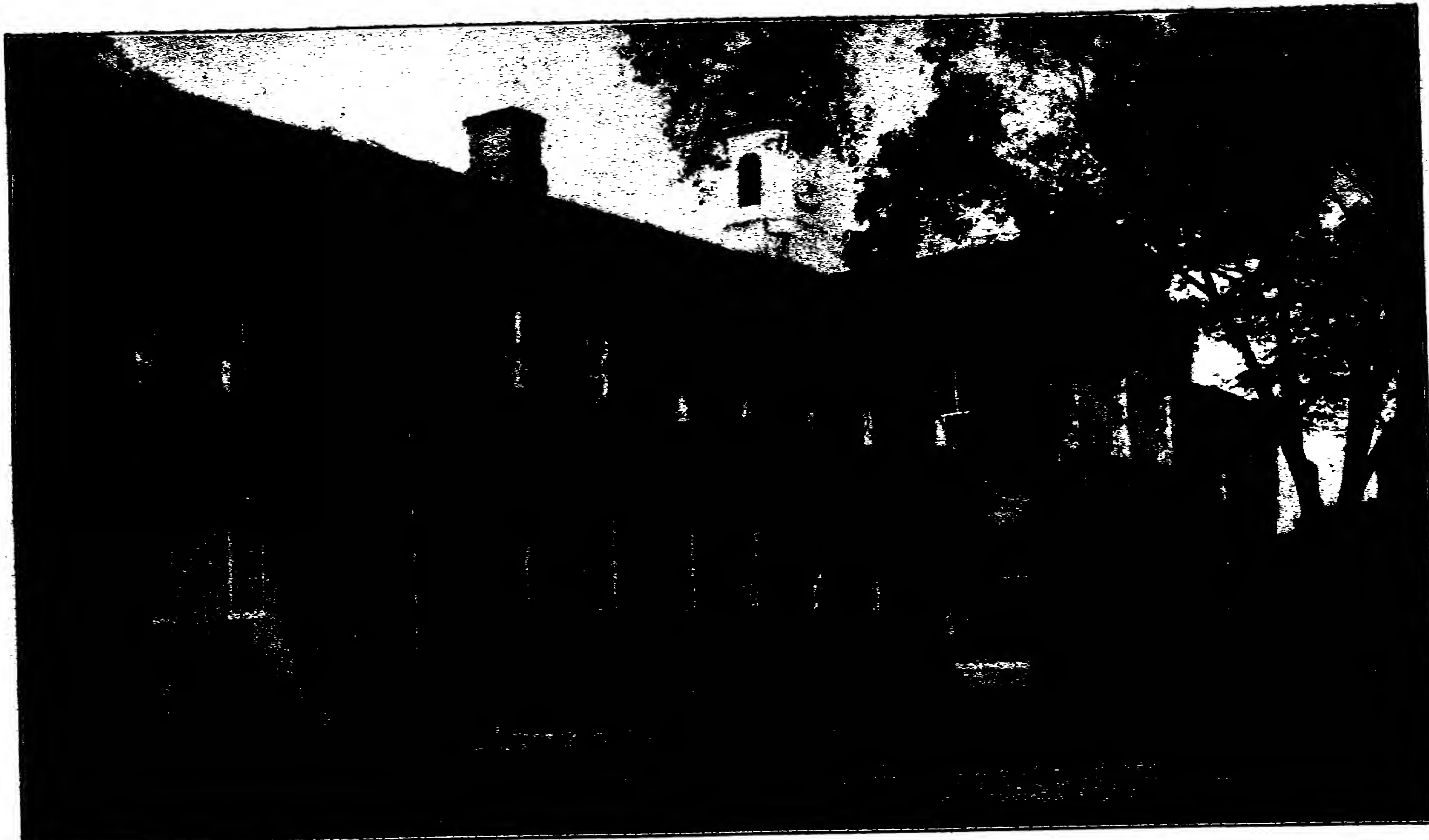
PAST PRESIDENTS OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION

THE PHOTOGRAPH TAKEN AT THE PHILADELPHIA MEETING SHOWS ABOVE, FROM LEFT TO RIGHT, PROFESSOR KNIGHT DUNLAP, THE JOHNS HOPKINS UNIVERSITY; PROFESSOR RAYMOND DODGE, YALE UNIVERSITY; PROFESSOR LEWIS TERMAN, STANFORD UNIVERSITY; BELOW, FROM LEFT TO RIGHT, PROFESSOR JOSEPH JASTROW, UNIVERSITY OF WISCONSIN; PROFESSOR CARL E. SEASHORE, UNIVERSITY OF IOWA; PROFESSOR HOWARD WARREN, PRINCETON UNIVERSITY; PROFESSOR MARGARET FLOY WASHBURN, VASSAR COLLEGE; PROFESSOR R. S. WOODWORTH, COLUMBIA UNIVERSITY.

not only by form and function, but by the chemical composition of every drop of blood or sap. The test tube reaction proving this, devised by the Russian Manoilov, has been simplified and made more precise by Sophia Satina and A. F. Blakeslee, of the department of genetics of the Carnegie Institution of Washington. The substances responsible for the reaction are sufficiently stable toward heat so they may be identifiable and they appear to be sugars similar to glucose. The extent of difference between the sexes in the physiological processes so measured depends upon the stage of life. In the case of flowering plants the leaves collected three or four weeks after flowering are most easily distinguishable as to sex by such means while the leaves gathered in the midst of the flowering period are so much alike in this respect that they can not always be distinguished by chemical means and indeed sometimes give the reaction of the opposite sex. In the case of bread moulds, where the opposite sexes are impossible to determine except by this test, the greatest difference is shown in well-developed culture of nine days old and is least apparent in older and younger. Dr. W. L. Aycock, of the Harvard Medical School, reported to the American Society of Bacteriologists that artificial immunization against infantile paralysis was accomplished in monkeys in about one third of the cases treated. Dr. Aycock and Dr. J. R. Kagan treated weakened strains of the causative virus with glycerine and carbolic acid in preparing the vaccines used. The immunized monkeys were able to withstand successfully injections of the active virus when the series of protective vaccination were completed.

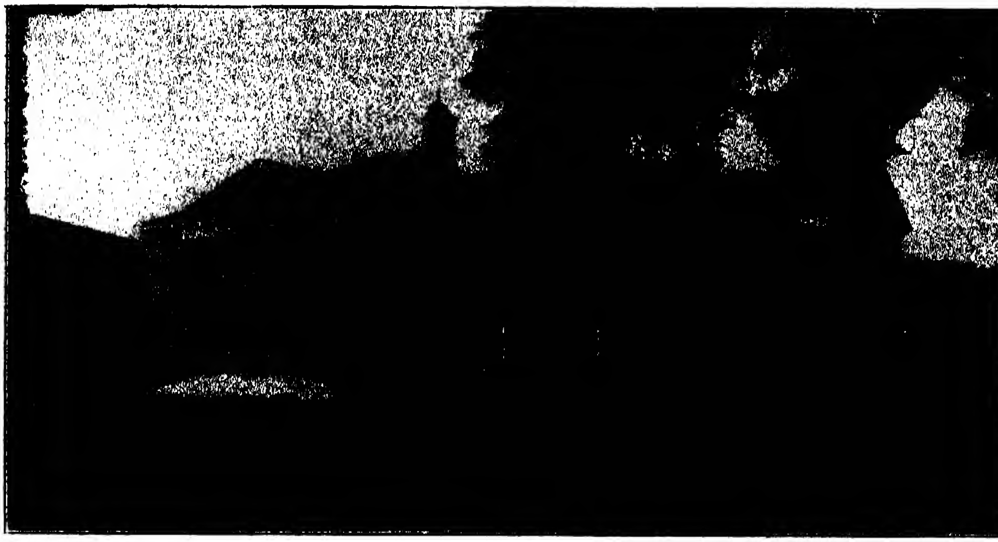
Diabetes may be due to infection by a virus too elusive to be discovered by the microscope. This is the inference of experiments on the cause of this dread disease reported by Dr. D. H. Bergey, of the University of Pennsylvania. He has found it possible to induce the disease by injecting rabbits with urine from a diabetic patient after filtering it through porous porcelain. This would indicate that diabetes belongs to that class of diseases caused by infection with a germ or virus so extremely minute that it can not be discerned with the most powerful microscope or caught by the finest filter. Yet Dr. Bergey shows that the diabetes virus can be cultivated and developed on serum broth when air is excluded, and after fifty-six hours is more potent than before in infecting rabbits. The discovery of this method of handling the causative agent of this mysterious malady promises to lead to methods of counteracting it or preventing its spread. Diabetes is one of the diseases which continues to increase in spite of the success of experimental medicine in other fields. The death rate from this disease more than doubled in the twenty-four years preceding 1923. Injections of insulin, the missing hormone, may prolong life indefinitely but neither the cause nor the cure has so far been discovered.

Dr. Aleš Hrdlička, president of the American Anthropological Association, subjected to sharp criticism the frequent reports appearing in the newspapers of finds of the remains of fossil man in America. The stories of the discovery of bones of prehistoric dwarfs or giants are obviously absurd and even the most plausible of such announcements lack substantial foundation. The sensational report by a curator of a western museum of rock carvings of man in company with extinct lizards and elephants was wholly erroneous. The row of teeth found in a slab of hard rock of Eocene Age and pronounced by one of the foremost dental journals to be human was found on closer scrutiny to be those of an ancient horse. There is no decisive evidence of the existence of man in America as early



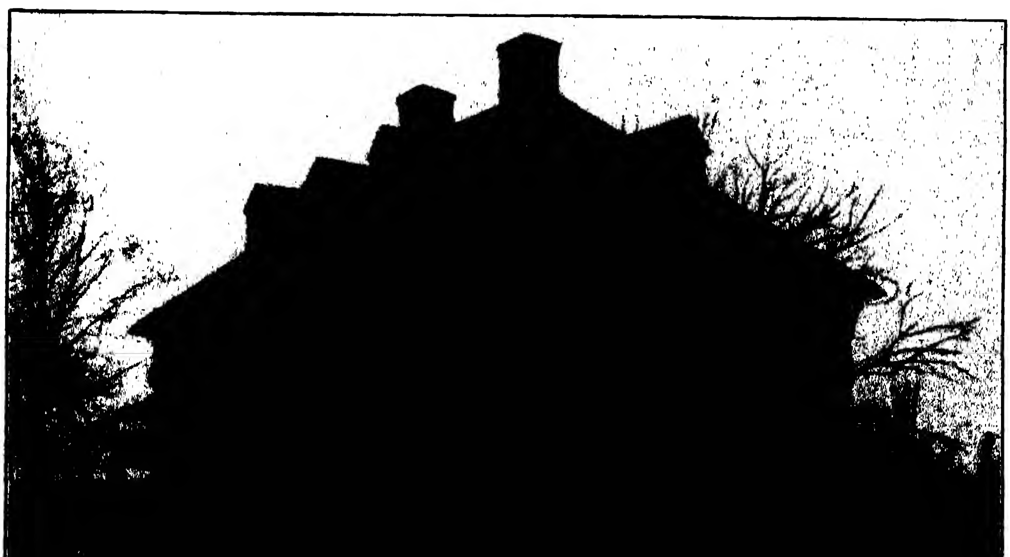
THE SIR CHRISTOPHER WREN BUILDING OF WILLIAM AND MARY COLLEGE

THE OLDEST ACADEMIC HALL IN THE UNITED STATES ERECTED IN 1693 AFTER THE COLLEGE HAD RECEIVED ITS ROYAL CHARTER FROM KING WILLIAM AND QUEEN MARY. THIS BUILDING STILL SERVES AS AN ACADEMIC HALL AT THE COLLEGE. IT WAS HERE THAT JEFFERSON, TYLER, MARSHALL, WYTHE AND OTHERS RECEIVED THEIR EARLY EDUCATION.



THE PHI BETA KAPPA MEMORIAL HALL OF WILLIAM AND MARY COLLEGE

Erected on the campus to serve as a memorial to the fifty founders of the great society which had its beginning at William and Mary in 1776. This building contains, among other features, a replica of the Apollo Room of the historic Raleigh Tavern of Williamsburg, where the idea of Phi Beta Kappa was first conceived. It was dedicated on November 27. Dr. Charles F. Thwing presided, and among the speakers were Dr. Henry Van Dyke, Dr. John Erskine and Dr. John H. Finley.



BRAFFERTON HALL OF WILLIAM AND MARY COLLEGE

Used as the first Indian school in the United States. Erected in 1723 from funds secured from the estate of Sir Robert Boyle, the prominent English scientific man, who set aside a portion of the revenue derived from his estate, Braffertonshire, to be used in connection with the College of William and Mary.

as the Glacial epoch or even of the arrival of any men, except the Indian and Eskimo, coming from other continents before Columbus.

Settlements of the men of the Old Stone Age found in southwestern Siberia were reported by Waldemar Jochelson, professor of ethnology at Leningrad University, now in the United States writing a book on the archeology of Kamchatka for the Carnegie Institution of Washington. He believes that in Manchuria, Mongolia and Siberia, the late Stone Age passed directly over into the Iron Age without passing through the Bronze Age which intervenes in western Europe.

Boys in Boston are taller than they were fifty years ago. Dr. Horace Gray, of the Chicago Institute for Juvenile Research, reported a comparison of the heights of boys of American-born parentage from six to eighteen years old measured by Bowditch a half century ago with those of the same age and parentage now, and he finds that in every year the modern boys are taller than those of the earlier generation. The gain in height varies with the age from 2.4 to 3.8 inches, averaging 3.2 inches. Dr. Gray ascribes the gain chiefly to progress in control of infantile diseases which so frequently damage growth and to knowledge of vitamins, sunlight and rickets with consequent better nurture.

The slight artistic deviations from the regular that bring beauty in music can be measured and charted by a phonophotographic method of music notation devised by Dr. Carl E. Seashore, of the University of Iowa, and demonstrated before the association. Ordinary notes are crude and inaccurate compared with Dr. Seashore's mechanically recorded curves that measure the tenderest emotion in music or speech. Even differences in mood of the singers are rigidly recorded by Dr. Seashore's charting of the actual sound waves, and collectors are using his method in recording primitive music for posterity.

Action in defense of freedom of speaking against governmental interference was taken at the American Association of University Professors meeting in affiliation with the American Association for the Advancement of Science. The report on "Freedom of Teaching in Science" by Professor S. J. Holmes, of the University of California, excited a lively discussion as to the best method of resisting such encroachments upon the rights of the teaching profession. Attention was called to the fact that in seventeen states bills will be presented to the legislatures this year similar to the North Dakota bill which provides that no theories shall be taught contrary to the biblical statements of the origin of man.

The association passed a resolution presented by Professor A. A. Lovejoy, of Johns Hopkins University, authorizing the Council of the American Association of University Professors and inviting other interested agencies to form an association for the maintenance of freedom of teaching in science. This organization would do all in its power to educate the public as to the danger of letting state legislatures restrain the teaching of the sciences and strive for a clean-cut division between church and state in this matter. The association also voted for an investigation of the legality of the action of the Texas State Text-book Commission in striking out "evolution" from the school books.

CORRECTION: In the article on "The Passing of the Professor" published in the January issue of THE SCIENTIFIC MONTHLY, it was incorrectly stated that the Reverend William Sunday had been "created a doctor of divinity by the University of Pennsylvania." The institution that conferred the degree on Mr. Sunday was Westminster College, Pennsylvania. The error may have been caused by widespread publicity given some years ago to an address by Mr. Sunday at the University of Pennsylvania.

THE SCIENTIFIC MONTHLY

MARCH, 1927

THE CONTRIBUTION OF SCIENCE TO THE WELFARE OF THE NATION[1]

INTRODUCTION BY THE CHAIRMAN

By Dr. JOHN M. COULTER

BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH

ONE of the most outstanding features of the sesqui-centennial period we are celebrating is the progress of science. In fact, during that period, it has revolutionized our civilization as to its methods and opportunities, as well as advancing our knowledge of the wonderful processes of nature. It is very fitting, therefore, to recognize this fact by arranging this symposium.

In the advance of science, it has become differentiated into so many separate fields of activity that it is impossible to include them all in a single program. We are beginning to realize, however, that what we call "science" is a great synthesis, all phases working together to produce the results. Formerly we worked in separate compartments, but now the partitions have been broken down, and our work is becoming more and more interlocking. In other words, science is becoming more like the work of an army than of independent scouts. There must be scouts, but the army follows.

[1] Program prepared for a meeting under the auspices of the American Association for the Advancement of Science to celebrate the one hundred and fiftieth anniversary of the signing of the Declaration of Independence at the Sesqui-Centennial Exposition, Philadelphia.

Speaking very briefly of my own subject, botany, I wish to call attention to its progress and to the great public service it can render. During the early part of our sesqui-centennial period, the only study of plants was their classification, really a cataloguing of our plant material. Now we find it is essential for the discovery of plants available for use, for food, for manufactures, for sources of important drugs, oils, resins and other materials. In other words, it is the kind of work that discovers our natural resources, like the discovery of valuable mines.

The second phase of botany which developed was the study of plant structure, to its minutest detail. We now find that knowledge of plant structure is needed by many industries, as illustrated during the great war, when it was applied to the production of explosives and to the timber used in aeroplanes. This is a good illustration of the interlocking of pure science and applied science.

Later, botanists began the investigation of how plants live and work. It was really the application of physics and chemistry to plants. We discovered what plants get from the air and soil. It will be appreciated at once that such

knowledge is fundamental in effective crop production. This work has certainly been an important factor in the revolution of our agriculture.

The next phase of botanical work was the study of plants in relation to their environment. What were called plant communities began to be recognized, which means that plants do not grow at random, but are associated in definite community groups. These groups were found to be the best indicators of soil conditions, and the practical application was to use these plant communities as crop indicators, that is, as indicating the kind of crop that would bring the largest return under these conditions. In fact, no phase of botanical progress has been without its important practical application.

Growing out of the previous phases of work, attention was drawn to the problem of forestry, an increasingly important problem as population increases and demands upon forests begin to exceed the supply. The problem was how to secure a perennial forest crop rather than to destroy this essential crop.

Next it began to be discovered that with all our developed knowledge of the value of plants and the effective method of their production, they were frequently attacked by destructive diseases, which neutralized all the other efforts. To meet this situation plant pathology began its career, and the result has been not only success in checking the ravages of disease, but in many cases the discovery and development of disease-resistant races of important crop plants.

Finally, the study of inheritance began to develop and has grown in a remarkable way. It began as very pure science, with no suggestion as to any practical service, but now it is being applied to the improvement of old crop plants, the securing of new crop plants, the development of drought resistant races, and the development of disease resistant races.

This bare outline of the progress and service of botany illustrates the situation in all the sciences. There is one fact, however, that we should always emphasize. This progress has not been due to the study of practice, for the study of practice alone is sterile. It has been due to the fundamental research which has advanced our knowledge, and incidentally this knowledge has suggested new practice. In other words, our increasing service, through better practice, is only a by-product of fundamental research. Even our present knowledge is relatively superficial, and the deeper we delve into research, the wider is the superficial application of our results. The fact is that men engaged in fundamental research are stimulated by knowledge for its own sake, and not by its possible usefulness. Knowledge, however, is essential to service, so that our progress in science, which may be likened to the exploration of an unknown continent, opens up new fields for cultivation. The spirit of the explorer leads him continually into new territory, and as he opens it up he leaves it to the practical farmer to cultivate.

There are three conspicuous tendencies in botanical research to-day, which will help us to forecast the future of research.

(1) The first tendency is to attack problems that underlie some important practice. This tendency was stimulated by the great war, for at that time botany was called upon to solve many important practical problems. This tendency is so strong at present that I do not believe it will ever subside, but it should be understood. There is no evidence that it is tending to diminish research whose whole purpose is exploration of the unknown; but our recent experience has shown us that many important practices suggest fundamental problems of pure research.

(2) The second tendency is an increasing realization of the fact that bo-

tanical problems are very complex, and must be attacked from several points of view. For example, in former days, in plant morphology we described structures, with no knowledge of their functions. Plant physiologists, on the other hand, described functions, with no adequate knowledge of the structures involved. Ecologists often described responses, with no adequate knowledge of either structure or function. This is all changing, and around each bit of investigation there is developing a perspective of other points of view and other methods of attack.

(3) A third tendency, which seems to me to be the most significant one, is the growing recognition of the fact that structures are not fixed to their last detail. Once, in morphology, in recording the facts of the development of an embryo from an egg, every cell-division was recorded, and also the plane of every division. It is becoming evident now that many of the recorded details were not significant, and we are having to distinguish those that are relatively fixed from those that are variables.

In conclusion, speaking for science as a whole, its present ideals may be summarized as follows: (1) to understand nature, that the boundary of human knowledge may be extended, and man may live in an ever-widening perspective; (2) to apply this knowledge to the service of man, that his life may be fuller of opportunity; and (3) to use the method of science in training man, so that he may solve his problems and not be their victim.

THE CONTRIBUTION OF BIOLOGY AND ITS APPLICATIONS

By Professor C. E. McCLUNG

UNIVERSITY OF PENNSYLVANIA

THIS is an age when all things are questioned. It is not inappropriate, therefore, for us to pause as we celebrate 150 years of our country's history to inquire what contributions science has made to progress during this time. One hundred and fifty years—what is such a period projected against the earth's history? How small a space of time, indeed, compared to the millennia of human existence! If extent only were a measure of value, surely we would have slight occasion to consider the years 1776–1926. But other criteria are more compelling, and, we believe, more valuable. Not actual but comparative time seems a better basis of judgment. To the biologist the measure of success in living is the accuracy with which organisms fit themselves into their environment. How thoroughly have they taken conditions and turned them to their advantage? In lower forms of life this means only survival. To man it signifies not only taking advantage of things as they are, but of shaping and directing these and creating new conditions and circumstances for his welfare.

The value of any period of time, therefore, finds its best measure in the degree of progress made in the control over natural conditions. For lower organisms adaptations are of infinite variety, but it is noted clearly that as complexity increases and we come to so-called higher forms, brain power is the measure of successful relations to environment. Because man possesses this in such an outstanding degree he has come, despite relative physical weakness, to a large command over all other creatures. Likewise, he has acquired some measure of

control over the physical conditions of existence. As between various groups of men, here, also, the mark of successful competition is in the exhibition of intelligence. When, eventually, destructive competition between races and individuals is replaced by a competition which includes cooperation, directed towards success in the common conquest of material existence, then an understanding of natural conditions and of human capacity and its utilization for the advancement of a comprehended cosmic plan will proceed with accelerated speed. The past 150 years have more than equalled the centuries before in such development—another such period at the present rate might reduce even the "wonderful century" to insignificance by comparison.

What, after all, is the measure of success in living? Is is personal well-being and happiness; is it merely being good and refraining from evil; or does it consist in some positive, constructive action? Even now it is considered necessary to render some form of service in order to be really successful, and this idea has been found not only worthy, but even immediately profitable. To most people, however, this idea of service is of some action which will benefit those about us. It is largely of the present and not of the future. Almost alone among constructive thinkers the scientist plans in terms of cosmic development. To him the past is of interest only as it is significant for the future. The world of to-day is not a static sphere upon which he prepares for an uncertain personal future, but rather a possibly comprehensible field of action upon which he plays a real constructive part. Always this part has been visioned more or less dimly by the world's great men, but only in these days, as a knowledge of the universe deepens and its infinite scope is revealed more clearly, does it begin to appear in what manner we are involved. And although in these 150 years we have traveled further than in all the millennia before in the comprehension of the realities of existence, as yet not much more than the method of progress has been revealed. Not by looking within, but by searching without, does revelation come. The scientific method, so old and yet so new, is the key which opens the doors of understanding. To us these doors now seem many, but the key is one, and the conviction grows that the final door that marks the convergence of all the paths which now pass through the portals marked "Physics," "Chemistry" and "Biology," and perhaps through others that we know not of, or do not now recognize, is leading to the final portal of "Science." Though the door to infinity be visioned as one, it, also, bears now many names. Those who seek by other keys than the scientific method to unloose the barriers to understanding do not see the name of science above the final goal. But the aspect of the thing matters not if we but regard the proper reality. My old friend, the good Kansas poet, Carruth, well phrases the matter in the poem "Each in his own tongue":

A fire-mist and a planet, a crystal and a cell,
A jelly-fish and a saurian, and caves where cave men dwell,
And a sense of law and beauty, and a face turned from the clod,
Some call it Evolution, and others call it God.

Without, therefore, making odious comparisons, but only in the interests of clear thinking and purposeful action, we must realize that what we see depends upon the direction in which we look and that the picture is colored by the glass through which we regard it. The beetling cliffs, the pounding waves, the scudding clouds, arouse the emotions of the artist and he pictures on the canvas his feelings regarding the eternal conflict between the inertia of the solid rock and the constant attrition of the flowing, streaming water. The scientist

looks upon the same scene and his imagination reaches out also and he visions the means by which it has taken form and, in the light of this revelation, he looks into the future and tells us what will happen as the years pass. There is no conflict between the visions of the artist and of the scientist. They are reflections of the same realities from two types of mind; from one a "sense of beauty," from the other a "sense of law."

If we would order our lives wisely, therefore, we must take thought of these differences and use each contribution in its place. To-day, accordingly, we will inquire, What is the character of the service to the common good rendered by the scientist? Here the poet has supplied the answer in the phrase "a sense of law." This it seems to me is the outstanding contribution of science. In place of chance, we see the earth in the light of laws which permit not only an understanding of what has gone before, but also enable us to vision the future. These laws we feel, not only in our common relations with environment, but we see them holding everywhere. There is always a sense of the inevitableness of a given effect from the same cause. The astronomer, looking through the telescope at distant worlds, finds the same chemical elements producing the same effects upon the physical instruments with which he measures chemical action. In all this scheme of reasonable law, man finds himself as the only creature capable of appreciataing it and taking part in it. As his knowledge increases, more and more it becomes possible for him to exercise control (at present largely only in matters of detail) but with the establishment of more comprehensive and far-reaching laws, control will become greater. As an instance of this it has been stated that an understanding of the method by which atomic energy operates would make available the command of energies so great that even disruption of the entire earth would be possible.

One outstanding lesson in our progress so far is that the scientific method provides the best means for determining conditions of existence and of providing the means for meeting them. To the final end of such understanding all divisions of science contribute, and it is not well to emphasize the service of one above the others. To-day one makes the chief contributions; to-morrow another. Each supports and contributes to the rest. Therefore, when I speak of the contributions of biology I do so not in an invidious way but merely to indicate how that portion of the general subject of science contributes to the common achievement.

It is desired in this symposium to indicate in what manner the applications of biology have been of value to the nation since its establishment. If I might very briefly indicate some of the valuable applications I would select three as the most outstanding. I believe it may be truly said that, consequent upon the results obtained from biological study, we live a longer life, a fuller life and a more purposeful one.

It may be well to examine a little bit in detail the basis for this opinion. According to the best information that statisticians can give us, the average expectation of life has been raised since 1855 from fifty to fifty-eight years, and, although the figures are not so exact for the preceding period, there was an increase of approximately five years from 1789–1855. This does not mean that the capacity for living has been increased, but only that the conditions have been made so much more favorable that at birth the average expectation has been to this degree increased. Compared, for instance, with the expectation of life in some of the less favored countries, the information is that these fifty-eight years lying before the average American in British India would be reduced to

22.6 years. In addition to what has been accomplished it is definitely stated by competent authority that if we should take advantage of present knowledge and make rigid application of it, the average expectation could be increased ten years. Here we have a clear demonstration of the fact that biological knowledge has made a longer life possible.

The results so far obtained do not indicate, in any large degree at least, a change in the character of the human material, but only in the possibility for its development—there yet remains the probability of actually changing its quality. It has been found feasible in the study of lower organisms, even with present knowledge, by genetical means to alter the inherent character of living material so that it actually exhibits a longer individual life. What has been done with these lower forms certainly can be accomplished with man when knowledge is increased, and, in particular, when a definite purpose lies before us. It was formerly the case that during the first year of life more than half of the children born would die. Quite aside from the human element involved there is here, of course, a tremendous material loss. It is more and more apparent that the individual has a social value and that a system of society which does not include an evaluation of this and fails to adapt its processes to the conservation of individual life is lacking in a fundamental attribute of success. At present social organization proceeds blindly without any appreciation of the value of the individual human life or of conditions which make it of the greatest group value. It would seem quite obvious that, with a given number of individuals living half again as long a time, their contribution to the social structure would be correspondingly increased. We may reasonably expect, then, that one of the contributions of biology will be a real prolongation of the individual human life as well as the improvement of the prospects of its continuance.

When we speak of the individual living a fuller life, the meaning would depend upon the point of view. I think, however, it may reasonably be said that by reducing natural phenomena to operations under given laws there has been removed much of the handicap which prevailed during periods when superstition largely took the place of understanding. At the present time the individual may proceed about his daily tasks quite undeterred by thoughts of vindictive demons or other taboos. There is a certainty about the conditions under which we live because we are largely freed from fears and inhibitions which come from ignorance. Perhaps one of the most outstanding evidences of this is the better understanding of the causes of disease. In former times when plagues swept over the world, often removing half of the population, there was no understanding of the cause of the visitation. Even in the most highly developed of intellectual states, that of Greece, at the time of the great plague, superstition and fear dictated all thought and action. When it became known that microscopic organisms, having definite life cycles and susceptible of attack, are the causes of disease, at once one of the outstanding uncertainties of life was largely minimized. It is true that we have much to learn even in this field, but the principles are known and the methods are at hand by which this greater understanding may be reached, and it is only a question of time, and that probably a very brief one, when most of the common infectious diseases will be banished from the world. From the earliest times a fear of disease and death has been one of the severest handicaps to purposeful action. In savage states the individual born into the world with a physical handicap is almost hopelessly started in life. With even our present improved methods of treating deformi-

ties and injuries, the person who is only physically disabled may look forward to a worthy and helpful life. Especially is this true in the case of children, where in many cases what would formerly have been a hopeless deformity is only an unpleasant incident in their lives.

Civilized countries now rarely face the prospect of severe famine. A knowledge of the plant and animal life has made possible the control of food conditions to such a degree that only very exceptionally does it become necessary to consider the prospect of food scarcity. Not only are the amounts of foods greatly increased through better methods of culture, but the qualities of these have been much improved. Also by proper genetical practice, entirely new forms of food products have been originated. From these and many other circumstances I think it may be truly said that biology has made a fuller life possible by the removal of both mental and physical handicaps.

But how shall we say that biology by its contributions has made a more purposeful life possible? Of all scientists, the biologist is most constantly confronted by the evidences of purpose in nature. No structure that he may find in plant or animal has significance except in terms of purpose. Upon the examination of a new structure, the first question that the biologist asks of himself is, What is the purpose of this? and only by answering this question can he come to an understanding of the presence of the unfamiliar structural condition. It is often held as a reproach to biology that its philosophy is so definitely teleological. But the facts must be faced, and the facts are that living things are explainable only in terms of purpose. If the structural conditions shown in all organisms are constant evidences of purpose, then most certainly their existence, and the existence of all organisms, is an evidence of larger purpose. It is unthinkable to the biologist that any living thing can exist and carry on its functions and depart from the earth without some definite accomplishment, and since in their individual structure and behavior the evidences of purpose are so manifest, then it can not be otherwise than that their presence is a part of a larger purpose which as yet remains without understanding. I should be inclined to say, therefore, that however valuable the contribution of biology has been to material existence, the demonstration which is so universally apparent in all its subdivisions, of an underlying plan, forms the basis for a philosophy of existence which has a very definite and demonstrable foundation. It is not a question of what one feels should be the circumstances of existence, but rather the demonstration of what these circumstances actually are. If the biologist is correct, each individual finds himself, therefore, with the basis for belief that his presence is a part of a large and even cosmic plan, in which, with sufficient knowledge, he can play a very much greater part than is now possible.

Through very extensive studies of living things, something over a half a century ago Darwin was able to place, with some degree of success, the age-long theory of evolution upon a basis of observed facts. The central feature of the evolutionary theory is that organisms are plastic in their nature and are constantly undergoing change. By observing the results of these operations it is noted that there has been formed a graded scale in degree of complexity from the very simplest to the most complicated forms. Paralleling this present complexity is a historical perspective which shows the simpler forms in the earlier periods of the earth's history and the more complicated at the present time. There have been millions and millions of these different kinds of organisms, many of which have completely disappeared. There are only two ways of accounting for this diversity; one is

that there prevails a continuous series, grading one part into the other progressively; the other is that each of these multitudinous kinds has been especially created as such and remains without change. There are no two opinions amongst biologists as between these possibilities.

An almost convincing demonstration of the evolutionary principle has entirely altered the philosophy of the whole world, whether appreciated by the individual or not. The whole texture of scientific thought is permeated by this conception of the relation of elements in the time series. It is by far the most hopeful philosophy that could be conceived, because always there is the possibility of change, and the history of the past has shown that this change is slowly but progressively towards greater perfection and beauty. If biology has rendered no other service to society than the establishment of such a philosophy of hope for development in the future, it would have served well.

SCIENCE, THE DECLARATION, DEMOCRACY

By Dr. J. McKEEN CATTELL

FORMERLY PROFESSOR OF PSYCHOLOGY IN THE UNIVERSITY OF PENNSYLVANIA AND COLUMBIA UNIVERSITY

JEFFERSON and Franklin were men of science as well as leaders of a revolution. Five of the fifty-six signers of the Declaration were physicians; one was a surveyor or engineer, as was Washington; others had scientific interests. More significant for the relations of science to the progress of democracy is the circumstance that our revolution, followed by the French revolution, was synchronous with the industrial revolution, which was caused by the applications of science. In legendary lore little James Watt may have watched the steam escaping from the teakettle on the same day that little George Washington cut down the cherry-tree. However that may be, Watt patented his steam engine in 1769 and it was first put to use by pumping the coal mines of Cornwall about 1776. We can celebrate here equally the anniversary of the political revolution that separated us from England and of the industrial revolution that began in that country. If we look about us at the buildings and exhibits of this exposition and then try to picture what happens in Harrisburg, Washington and Geneva, we can compare the extent to which each revolution has accomplished its objects.

The industrial revolution, beginning with the exploitation by machinery of the coal and iron of England, has not only given us our material civilization, it has also laid the foundations on which social and political democracy can be built. When the feudal system yielded to the industrial system, the wealth created by the applications of science made democracy feasible. Social aristocracy survives in England, but that nation has on the whole led in the development of political democracy, as it has in the manufacturing and in the world-wide trade that are the children of science. The mother of parliaments has had a labor-socialist government; the British flag has followed the commerce on which the sun never sets. Germany by the applications of science to industry became a rival of England with results temporarily disastrous to the world. The United States has now outdistanced them both, with a future that lies on the knees of the gods. History is controlled by economics, economics by the applications of science.

It is often said that science is not concerned with matters such as democracy, liberty and the pursuit of happiness, that all it can do is to supply knowledge as likely to be misused as to be applied for our welfare. But a psychologist, who by profession is concerned with the study of human behavior, has been asked to take part in this program. He does not hesitate to claim that science has been the creator of the modern world, a force more potent than any religion, than any system of laws, than any form of government. The advance of science is not dependent for its results on these, whereas religious, social and political institutions are on the one side based on the truths determined by science, on the other side on the economic conditions caused by the applications of science.

Men have died for their country, right or wrong; for their religion, true or false. The martyrs of science have been comparatively few, but it is science that has led the way to true freedom of thought. The patriot and the saint are partisans. Our poet may say:

> Truth forever on the scaffold
> Wrong forever on the throne.

But the balance is pretty evenly weighted. Those with the power, whether in state or church, have ever been ready to impose their creeds and their control upon others.

Far be it from a psychologist to claim that men of science are not also partisans. But we are such as men and not as students of science. He is no longer a scientific man who tries to force others to accept the discoveries that he makes, the laws that he finds, otherwise than by stating them and by using them. Know ye the truth and the truth shall make you free. If it is asked how the scientific man knows the truth, the answer is that he does not. He makes approximations and the bank of his knowledge is solvent so long as it honors his drafts. The Euclid-Newton bank honored until recently all the drafts that were drawn on it. It appears that it may fail to do so for some little ones; if this proves to be the case then our physical universe must be revised or discarded. It is equally true that no social system, no political theory, no religious creed, can be maintained when it is not in accord with science. The methods of science, slowly gaining in force and volume through the centuries, will in the end bring truth and reason into all our beliefs and actions. At least that is the hope of the world, for we can not rely on inherited instincts to meet situations always increasing in complexity.

There can be no conflict between science and religion, between science and nationality; neither are they separate spheres that do not touch. Metaphysics and theology, religion and art, declarations and constitutions, may be true or false, beautiful or ugly, useful or harmful; these are all facts open to investigation, however ignorant we may be at the present time in regard to them. For me there are no more beautiful words than "In the beginning God created the heavens and the earth." Whether the story of the first chapter of Genesis is a true account of what happened six thousand years ago is a question of fact. It is absurd to try to reconcile religion and science when there can be no conflict. The bison had the prior possession of the prairies, but it is futile to try to reconcile the right of one of them to stand on the railway track with the right of the locomotive engine to run over the track. A debate between Dayton and Darwin is appropriate only to the rural vaudeville stage.

There are doubtless influential scientists who would not agree with these remarks. Some of them have recently joined with clergymen and publicists in a manifesto reconciling religion and science with the help of the ambiguous use of words. One of them claims that

if psychologists do not find evidence for the soul, it will be saved by a paleontologist and two physicists. We all agree, however, that while we may dispute concerning matters of which we are ignorant, we shall accept the verdict of science when it is rendered. William James may be correct when he claims that we have the right to believe any hypothesis that is sufficiently alive to tempt our will, for he makes the essential reservation. Once he said to me when discussing the optimistic and pessimistic views of the world: Some people may see a checker-board as white with black spaces, others as black with white spaces; why should we not side with those who see it white? The obvious answer was: Why not see it half white and half black?

The Declaration of Independence begins with the statement that it is a self-evident truth "that all men are created equal." This appears to be more comforting than Calvin's conflicting claim that some infants are born to be damned. But no statement in the Declaration, whatever the reverence in which we may hold it, and no dogma of a church, however great its historic authority, can be maintained, if it is contrary to the results of scientific investigation. The first psychological measurements of individual differences were made by me. We now know that men differ not only in size of body, but also in what with equal opportunities each can do. New meanings may be read into the words of declarations and creeds, but that is not the way to respect them. It is far better, as does the scientific man with his superseded theories, to honor them as the dead bodies over which we have advanced.

There are no self-evident truths; all men are born unequal. Democracy should not claim that all men are equally fit to do anything; it is more nearly a system by which all can attain the positions for which their native inequalities fit them, without help or hindrance from privileges of birth and property. As a matter of fact the Declaration is not particularly concerned with defining or forwarding democracy. It is a Declaration of Independence rehearsing the "repeated injuries and usurpations" of the king of Great Britain and maintaining the right of revolution to redress these wrongs. There is nothing in it incompatible with setting up a hereditary monarchy of our own; Jefferson and Washington were fit to be the founders of a landed aristocracy.

The Constitution, like the Declaration, was not written in the interests of democracy. It adopts a system of checks and balances adverse to popular government; its provisions making amendment difficult, indeed its very existence, are undemocratic. It is a fine defense of individual liberty and some of us may wish that its spirit were still a living force. There is a certain absurdity in adding the eighteenth amendment to the early articles maintaining the freedom of speech and of the press, the right to keep and bear arms, the limitation of searches and seizures, and the right to trial by jury. Legislation such as the recent sedition laws is subversive of the principles on which the nation was founded. Modern social democracy must, however, limit individual freedom for the general benefit. The complex civilization created by the applications of science requires controls that would have been intolerable for the colonists of the eighteenth century.

True democracy has become feasible only since the Declaration was signed one hundred and fifty years ago. When the *Nineteenth Century* magazine asked various notables what were the chief advances of that century, democracy and science were most frequently referred to, these two being named by individuals so diverse in their interests as Gladstone and Jenny Lind. But probably neither

of them realized that the applications of science are the prerequisite of democracy.

We still await greater production of wealth through the applications of science and its more equitable distribution for the further advance of democracy. England has at present a partial political democracy and a rather complete social aristocracy. Russia has more nearly a social democracy and a political oligarchy. We live under a limited social and political cleptocracy. The word may be a bit harsh, but we should learn to subsume under the eighth commandment the securing of political office and legislation by money or favors, and the obtaining of more money than services are worth by inheritance, privilege, monopolies, tariffs and the like. It is fortunate that science provides so much real wealth, even though it may not yet have taught us how to distribute and use it properly. We may hope that the superstructure of paper wealth, which gives the few the control of the many, may in the end be rebuilt by science for the housing of democracy.

Wealth is not an ultimate good, but a means to other ends. It is an essential means to democracy in the modern world. A kind of democracy is more or less feasible in a primitive tribe, though it is doubtful whether it has ever existed, there having been always a patriarchy or other hierarchical organization. When, however, needs are simple and nature provides for the necessities of a small group, there can be a kind of equality without excessive labor and apart from the applications of science. But in fact science begins with the first tools and the most primitive industries; the advance of civilization has been entirely dependent on the accumulation of knowledge and its wider applications.

The earliest civilizations, Egypt, Babylon and the rest, were made possible by the beginnings of science, but in that stage of development human slavery was necessary. One of the Egyptian pyramids is comparable in size and cost to an office building in New York City. The pyramid required the labor of thousands of slaves working for many years. They toiled as many hours a day as they could be kept standing by the lash; their women and children worked in equal measure. The pyramid served as the tomb of a king. The modern office building may be built by a comparatively small number of men working eight hours a day for a few months. Each man is paid what would have provided for the subsistence of a hundred Egyptian slaves. His children must go to school and can go to college. The office building may be used by ten thousand people.

The great civilizations of Greece and Rome were based on slavery. Athens had perhaps thirty thousand citizens and three hundred thousand slaves; it drew on subject nations, and the city, as always, was parasitic on the country. Rome conquered the world. In distant Palestine Christ said: "Render unto Caesar the things that are Caesar's," but just why the hard-earned pennies of the Jewish peasants were Caesar's is not clear. There is no word against slavery in either the Old or the New Testament. A civilization based on the control of the many by the few and the support of the few by the many could endure only by force. The barbarians from the north, the rustics, the submerged classes, overthrew it, and there were larger groups having opportunity and the chance to rule.

There gradually emerged civilizations in Italy, Spain, France, Germany and England. Chaucer and Dante were born. Guilds were established. The universities of Bologna, Paris and Oxford arose. Roger Bacon was born at the time King John was forced by the English barons to sign the Magna Charta. Constitutional government and

trial by jury were established. Greater democratic control parallelled the advances of science. Copernicus was nineteen years of age when Columbus reached America. New heavens and a new earth were then created. Science and democracy advanced together until the time of the industrial revolution and of our revolution when there was an inflection point on the rising curves of each. But always it was science that led in more correct knowledge of the world, in providing wealth that supported larger numbers of free and educated people.

Lincoln and Darwin were born on the same day; the slaves of the south were emancipated and the Origin of Species was published at nearly the same time. Legal slavery will never again exist; freedom of thought will never again be openly suppressed. Our task now is to do away with the subordination of the individual and the limitation of his freedom by economic, social and political controls. We must get sufficient wealth and so distribute it that every child will have opportunity to do what he can do best; that every one will have the chance to read, talk, think and live.

It does not follow that because science provides the nearest approximation to the truth for the time being attainable that people will accept it, or that if they do it will apply to their behavior. As the Latin orator said long ago, we see the better things but follow the worse. Neither do we have general education, leisure and democracy because the wealth provided by science makes them possible. Our material civilization has been created within five hundred years; man has scarcely altered in ten thousand years. In so far as there has been a change it is probably in the direction of a weaker muscular system less well coordinated, defective senses, greater susceptibility to disease, less adequate responses to simple and fundamental situations, including the more elemental emotions and the finer forms of art.

Material science has done its part by giving us more knowledge of the physical and biological world and by supplying those applications which make it unnecessary that there should be slavery, the exploitation of races, the subjection of women, child labor, excessive manual toil. Birth rates and death rates have been reduced to one half; the length of life has been doubled. It is not reasonable to blame physical science because people do not use to the best advantage the opportunities that it has provided. Nitrogen may be employed for fertilizing the soil or for killing men; universal schooling does not determine what people will read; wealth may be seized by a few instead of being used for the general good.

Human behavior is the concern of the psychological sciences. If it is asked why these have not accomplished more, a simple answer may be given. Psychology is a new science. The first chair of psychology in any university—held by the present speaker—was established at the University of Pennsylvania in this city less than forty years ago. The physical sciences have had centuries for their development, psychology only a single generation. It is futile to predict, but we are within our rights to hope, that the psychological sciences will in the end contribute in equal measure with the physical sciences to our knowledge and to its applications for our welfare. For example, it is not unreasonable to guess that the average productivity of each individual could be doubled and his happiness correspondingly increased, if he were selected for the work that he can do best, trained in the right way to do it, and given the most favorable conditions. We may further hope that in addition to its economic applications, psychology, even more directly than the other sciences,

will advance those things that are most worth while.

On a patriotic occasion such as this, we can date modern science and the new social era from the time of the discovery of America, the applications of science and the democracy made possible by them to the time of our revolution, the modern extension of scientific knowledge and its dominant place in civilization to the time of our civil war. It is our part to see to it that the world supremacy that our nation has now attained may mark the era in which science and the resources that it creates are used for the welfare of all.

AMERICA'S OPPORTUNITY IN CHEMISTRY

By Professor WILLIAM A. NOYES

UNIVERSITY OF ILLINOIS

Some time ago statistics were published which stated that before the war there were thirty thousand chemists in Germany, five thousand in England, two thousand five hundred in France and fifteen thousand in the United States. I doubt the entire accuracy of these figures and the training of chemists and the standards for the profession differ so much in the different countries that it would be useless to attempt more than a very rough comparison of this type. It seems rather certain, however, that the nations mentioned ranked somewhat as indicated, in their chemical development. Before the war America had already laid good foundations for a rapid advance and this was greatly accelerated—perhaps too much accelerated—by the war. In Germany, on the other hand, the conditions for chemical development have not been favored and it seems reasonable for us to look forward to a time when America will take the first rank in chemistry. With this possibility in mind it is worth our while to inquire how Germany secured the position she holds and what we must do to secure a similar position.

Just about a century ago, in 1822, a young man, only nineteen years of age, went to Paris to study chemistry and had the good fortune to gain admittance to the laboratory of Gay Lussac. That was only eight years after the Napoleonic wars, when France and Germany had been bitter enemies, but chemistry was at a very low ebb in Germany and Liebig went to Paris to study chemistry with Gay Lussac, as his most intimate friend, Wöhler, went to Sweden to work with Berzelius, the greatest chemist of the time. There is such a thing as scientific heredity. It differs from physical heredity in that a man may choose his own father. Liebig chose Gay Lussac; Wöhler chose Berzelius; and several Americans still living are in the second or third scientific generation from Liebig.

In 1824 Liebig was called to Giessen as assistant professor of chemistry. There he founded a laboratory new of its kind in the world—a laboratory where teacher and students worked together intensely and enthusiastically in gathering new knowledge and building, systematically, advances in the science of chemistry. To that laboratory men came from all over the world and from that laboratory influences went out that touch every chemist and, indeed, every individual who has any part in our modern life.

Liebig's laboratory was small and crude in comparison with the palaces in which we work to-day and the knowledge of chemistry of the time was also small and rather easily mastered so far as Liebig thought this necessary for the beginning of constructive research. But to Liebig and to all those who have in-

herited something of his spirit the laboratory was not primarily a place for acquiring a knowledge of chemistry—it was a workshop where chemistry was made—where students did not so much follow the suggestions of some leader as where they gained an inspiration to strike out into new and untried paths of their own. He antedated a saying of Le Chatelier, "Young people are not receptacles to be filled; they are fires to be kindled."

One of the men who worked in Liebig's laboratory was A. W. Hofmann. In 1845 Prince Albert called Hofmann to London to teach in a newly founded college of chemistry. Ten years later he had as an assistant, William H. Perkin, a young man of nineteen, who was not content to merely work with Hofmann during the day but fitted up a small laboratory at home where he could work at night and on holidays. He thought there might be a relation between aniline and quinine because of an apparent relation between the formulas of the two, and on this basis attempted a synthesis of the alkaloid. We now know that there was not the slightest chance of success. Instead of quinine he obtained a colored compound. As he reports, chemists at that time did not think much of colored compounds and looked on them as impurities to be removed by bone black, or otherwise. Perkin was struck with the beauty of the compound and, perhaps partly because he was young and enthusiastic, he conceived the idea that the new color might be used as a dye. Fortunately, the father of Perkin had faith in him and furnished the capital to start the new industry. The problems the young man had to face in converting his laboratory preparation of mauve into a successful manufacturing process were varied and difficult. Benzene, which had been discovered in oil gas by Faraday in 1825 and was known as a constituent of coal tar, was not to be had as a commercial product and it was necessary to go to the manufacturers of gas for a crude product to be purified. Then the nitration of the benzene and the reduction of the nitrobenzene to aniline, known before then only as small scale laboratory preparations, must be carried out on a large scale in a factory. Even when the dye had been made, the dyers, accustomed only to the use of vegetable dyes, such as indigo, logwood and fustic, did not know how to use it and Perkin had to go into the dye houses and show them how to handle the material. All these difficulties were overcome and the foundation was laid for a great industry which has revolutionized the beauty of our wearing apparel.

A few years later Baeyer began an intensive study of indigo. Incidentally he discovered that by distilling certain compounds with zinc dust the oxygen they contain may be removed or replaced by hydrogen. Two other German chemists, in another university laboratory—notice that it was in *university* laboratories that Baeyer and also Graebe and Liebermann worked and not in factories—applied Baeyer's method to alizarin, the dye of Turkey red. They obtained anthracene and found the key to the structure of the dye. Shortly after, they made the dye synthetically and some attempts were made in Germany to manufacture alizarin. But it was W. H. Perkin, once more, with his years of experience as a manufacturer, who converted the laboratory synthesis into a commercial success.

With such a brilliant beginning it would seem that England should have continued the leader in the manufacture of artificial dyes, but long before the end of the nineteenth century Great Britain had lost all her initial advantage and Germany became preeminent in the production of synthetic colors.

When we look for the reason for this

surprising result we find it almost entirely in the laboratories founded on Liebig's ideal—laboratories where students learned the chemistry already known, it is true, but where, much more than that and as their prime object, teachers and pupils gave their energies intensely and incessantly to the development of an ever-changing science. Young men trained in such an atmosphere proved to be the very ones who could solve the varied problems of an industry which is so intimately connected with investigations in pure science.

In addition to the supply of trained chemists furnished by the universities, there grew up a most intimate connection between the university laboratories and the factories where dyes were made. In the olden times artisans and philosophers were entirely separated and the experimental method made little progress in science. That method is now thoroughly established and we see clearly that we can gain new knowledge only by bringing our ideas constantly to the test of agreement with objective facts. A condition somewhat similar to the old divorce between ideas and experiment still continues in some of our industries and universities. The "practical" men of the industries think they can get little help from science—and some scientific men think it is beneath their dignity to have connections with the industries.

While professors in German universities have continued to devote their energies to the development of the science of chemistry rather than to industrial applications of their knowledge, many of them have maintained intimate relations with the directors of factories and these relations have been mutually helpful. An illustration will help to make this clear.

Kekulé, one of the men who worked with Liebig at Giessen, proposed his theory of the structure of benzene in 1865. This has become, perhaps, the most important single fact guiding the work of the color-chemists even to the present day. Baeyer, who had studied with Kekulé, took up, in the same year, some work on isatin, an oxidation product of indigo. He tells us with what pleasure he had spent for a piece of indigo a birthday present of two thalers, given him when he was thirteen, and with what a happy, almost reverent feeling he drew in the odor of orthonitrophenol as he prepared isatin from the indigo by the directions he found in an organic chemistry.

After working with isatin and other derivatives of indigo for four years with good success Professor Baeyer dropped the subject for some years because his former teacher Kekulé published a paper in which he announced that he was attempting a synthesis of isatin. After waiting eight years, it became evident that Kekulé had not succeeded in his synthesis and Baeyer returned to the subject. Three years later he discovered a synthesis of indigo of sufficient promise for a patent and the Badische Anilin Soda Fabrik began at once an attempt to put the synthesis on a manufacturing basis. The chemists of the factory worked over the process from every possible point of view for fifteen years. The various steps of the process were greatly improved and more than a hundred patents were taken out but it was never possible to convert Baeyer's synthesis of indigo into a successful manufacture on a large scale. The original substance required for that synthesis is the toluene of coal tar and the annual production of this substance would be sufficient to make only one fourth of the indigo required in the world. As toluene is used in the manufacture of a great variety of other dyes and compounds, it is evident that any

considerable use for the manufacture of indigo would cause such an increase in the price as automatically to stop the manufacture.

The laboratory found its way out of this *cul-de-sac* by means of a discovery made in the chemical laboratory of the Polytechnic at Zürich, Switzerland—a laboratory which has given us many brilliant discoveries in chemistry and which is conducted on a high scientific plane, not on the theory that it should devote itself to so-called practical problems. By combining Heumann's discovery with another made by Hoogewerf and van Dorp in a university laboratory in Holland it became possible to manufacture indigo with naphthalene of coal tar as the starting point. Naphthalene, known to us all in the familiar moth balls, is abundant and cheap.

Even with the aid of these fundamental discoveries from the university laboratories the chemists of the factory continued to work incessantly on the problem for seven years before they were so sure of their ground that they recommended the building of a plant to make indigo on a large scale. The firm was then willing to spend four and a half million dollars on their plant for the manufacture of this single dye.

Many other interesting details might be given about the development of the manufacture of indigo but enough has been said to illustrate the intimate connection between the dye industry of Germany and the scientific work going on in university laboratories. Here, as in all branches of our modern national and international life, the only way forward lies in cooperation. If we can learn the full meaning of that, the possibilities of advance seem almost unlimited.

While I am emphasizing the training of men in methods of research and the intensive prosecution of research in our universities as the most essential foundation on which we must build if we are to take the first rank in chemistry, it does not follow that we must follow exactly the same lines that have been followed in Germany.

Nearly twenty-five years ago a man who had been trained as an undergraduate at the Massachusetts Institute of Technology and who had followed this with three years of work in the laboratory of Professor Ostwald, in Leipzig, was asked to take charge of a research laboratory for the General Electric Company at Schenectady. I have been told that for a time Dr. Whitney taught on Monday, Tuesday and Wednesday at the Institute in Boston, and worked in Schenectady on Thursday to Saturday, spending two nights a week on the sleeper going back and forth between the two places. It was not long before he discovered the method of "metalizing" carbon filaments for electric light bulbs and it is said this discovery was worth a million dollars to the company. The firm soon decided that they wished him to spend all his time at Schenectady, but he is still non-resident professor of chemical research at the Institute of Technology. As director of an industrial research laboratory, now probably the greatest of its kind in the world, Dr. Whitney has retained very much of the spirit and methods of the university laboratory. His men gather to discuss their research work, as the men of a university do, and some of them are engaged on problems which have no immediate industrial application in view. The contributions to the advance of chemistry which have come from that laboratory are very important and it is looked on as a model of its kind.

A few years ago our sailors were in danger of having to go out to meet the submarines, blind, because no one in America could make the optical glass necessary for their instruments. To whom did we turn in the emergency?

Was it to the manufacturers of glass? No! We turned to men trained for many years by research at the Bureau of Standards and at the Geophysical Laboratory in Washington where they had been studying silicates, not to make optical glass but to learn how the rocks in this old earth of ours have been formed. These men were able to solve the problem and within a few months, with the aid of a glass manufacturer, they had furnished six different kinds of glass required for the ordinary marine glasses and other optical instruments for the navy and army. Soon after, there was a call for a seventh glass with different properties. The men had worked out what is known as the triaxial diagram for silica, potash and litharge by means of which they could predict the relation between a glass made from these ingredients and its indices of refraction and dispersion. They located on this diagram the composition of a glass having the desired properties, put the ingredients together and it came out right the first time. Such is the difference between the old cut and dry methods of so-called practical men and a genuine scientific method.

The Royal Institution in London was founded in 1799 by Count Rumford, an American who had found Europe more congenial after our Revolutionary War. It has been stated that the support of that institution for the first century of its existence cost, on the average, only about twelve hundred pounds a year. But think, for a moment, what that six thousand dollars a year has meant to the world! It was there, in the early years of the nineteenth century, that Sir Humphry Davy made his startling discoveries in electrochemistry which laid the foundation for all our electrochemical industries. There, a few years later, Faraday discovered that a magnet thrust into a coil of wire generates an electric current and that an electric current may cause a magnet to rotate about it. These are beginnings from which all our modern electrical machinery has developed.

One of the features of the Royal Institution has been the giving of popular scientific lectures. The story is told that an old gentleman was accustomed to attend these lectures very regularly. He would come in and seat himself in one of the front rows and when the lecture was well started he would fall asleep and sleep all through the address. When the will of this old gentleman, John Fuller, was opened, it was found that he had left a bequest of ten thousand pounds to the Royal Institution "In memory of many happy and profitable hours spent there"—it sometimes pays to cultivate those who sleep through our lectures.

I have spoken of the absolute separation between the old philosophers and the artisans and of the somewhat similar attitude of those university men of our own time who wish to hold themselves entirely aloof from the practical affairs of life. There is, undoubtedly, some justification for this attitude for some of our university men have been drawn away from the pursuit of science to the pursuit of dollars, very greatly to the detriment of science. This is not altogether the fault of the scientific men. The annual per capita value of the material products of the United States is four times as great, in gold values, as it was in 1880. This means that the salary of a professor in a university should, in justice, be four times what it was in 1880. The wages of laboring men have gone up somewhat in the proportion that is just and the rewards of the leaders of our industries have certainly increased, at least in proper proportion, but the returns to academic men have not yet increased as they should. I think that I have made it clear that our great advances in industrial chemistry rest on the work of the universities for

their foundation. This seems to be well recognized and the great gifts to our laboratories from fortunes made in the industries are a concrete expression of this recognition, which we may hope to see increased. The same thought is slowly making its way into the minds of legislators, as shown by the increasing appropriations for state universities. Its recognition by Congress is still far from satisfactory, and unless this can be remedied the splendid record of the scientific bureaus of the government can not be maintained.

In one respect we may claim to have attained a better ideal than any other country. We have united all classes of chemists in a single society which has become much larger than any other chemical society in the world. By uniting our forces for publication and for the promotion of the interests of chemistry and of chemists we have demonstrated the very great advantages of cooperation. Our members sometimes object that we furnish them with a great deal of material which they can not use or in which they have no interest. In such a connection a comparison with the daily newspaper often comes to my mind. There are always many things in the paper for which we, as individuals, have no interest but the success of the paper depends on its appeal to persons with very varied interests and to the fact that each of these finds something of value. In France, the daily papers have, apparently, followed the plan of publishing a great number of different papers each of which is found agreeable to a comparatively small class of people. I am sure that most people who have followed these papers find them far less satisfactory than the large English and American dailies. Somewhat the same principle has been followed in publication abroad and especially in Germany. Our four journals cost our members only $15.00 a year, while the *Chemisches Zentralblatt* alone costs the members of the German Chemical Society $20.00. Only a comparatively small number of the papers giving an account of new research work are published in the *Berichte*, which corresponds most closely to our *Journal of the American Chemical Society*. At least eight or ten German journals would be required to get as good an oversight of chemical research in Germany as we can obtain for America from the two journals, the *Journal of the American Chemical Society* and *Industrial ond Engineering Chemistry*. As our research grows in volume and quality, however, there may be some question whether we can continue indefinitely our policy of the past twenty-five years. Indeed, we already have a *Journal of Physical Chemistry, Journal of Biological Chemistry* and *Journal of the Electrochemical Society* as well as a considerable number of journals devoted to special fields of industrial chemistry.

During the year following the armistice a young man who had seen service in France wrote me, "I am not so happy as I was then," referring to the days when he was in the army. He had in mind that many nations were working together as one man to win the war and that the men did so in a spirit of patriotism and devotion to the cause which had disappeared as the opposing national and individual interests came to view in the peace conferences. Must this be so? We have seen that a dozen nations can unite for war. Is it impossible for them to work in cooperation for the common interests which bind them so closely together in times of peace. Capital and labor united in prosecuting the war. Is it not possible for them to see their mutual interest in working fairly together for the advantage of the community?

As we look back through the ages a fundamental principle stands out—that

nation or class or individual who is willing to forget his own personal advantage when it conflicts with the advantage of others, gains, in the end, most happiness and advantage for himself; but the nation, or class, or individual who seeks first his own advantage with no thought of the good of others loses all that is most worth while in life. And we shall see, as we think of it, that this is the simple lesson taught nineteen hundred years ago—"He that saveth his life shall lose it, but he that loseth his life shall save it."

ENGINEERING AND THE NATION

By Dr. D. S. KIMBALL

DEAN OF THE COLLEGE OF ENGINEERING, CORNELL UNIVERSITY

THE story of man's upward progress from savagery to civilization is largely the story of his efforts to develop tools wherewith to subdue a stern, and on the whole, an unfriendly environment. That this fact has been deeply impressed upon him is evidenced by his recognition that this progress is marked by certain special improvements in his tools and methods; hence we speak of the Stone Age, the Bronze Age, the Iron Age and the Age of Steel. And it is quite evident that we are even now passing into a higher, and we hope a better, stage of civilization, the metallic index of which we can even now dimly visualize. It is true of course that certain of the older nations attained a high degree of culture with a handicraft background, but such culture was necessarily confined to a very few, the vast majority toiling as slaves in order that a limited number should have the things of life all men prize. But there is no record of widespread physical well-being, education and intelligence supported by handicraft; and axiomatically as the tools of industry become more and more primitive the status of the worker approaches more and more that of the slave.

Industrial development has progressed along three well-defined lines, namely, *labor-saving* machinery, *time-saving* machinery and machinery for *transmitting intelligence.* All three of these lines of endeavor have occupied men's minds from time immemorial, but it has remained for the scientists and the engineers of the last century and a half to really make machinery and scientific apparatus that have revolutionized not only our manner of living but our *ideals* of existence as well. It is fitting, therefore, at the close of the third half century of our national life during which these great developments have occurred to review the progress we have made since the last great celebration in this city that marked the hundredth milestone of our national existence.

From the very beginning of his mundane career man has recognized that he could greatly help himself by bringing to his aid the forces of nature, such as wind and water. The development of prime movers such as the steam engine and the gas and oil engine and the harnessing of water powers is a direct result of this ancient need. The progress in this direction during the last fifty years is most remarkable. The great Corliss engine built by George Corliss himself to operate the machinery of the Centennial Exposition of 1876 was considered to be a mammoth machine of epoch-making importance. It was rated at 1,400 horsepower. To-day we have single hydroelectric units that develop 70,000 horse-

power, and steam-driven turbo-generators sets that develop 60,000 horsepower in a single unit are becoming commonplace. The first locomotives weighed three or four tons, while modern locomotives weighing 300 tons are now quite common. The *Clermont* would barely make a tender for the *Leviathan*, and as high as 100,000 horsepower has been installed in a single torpedo-boat destroyer. More important still Mr. Fred Low computes that the total installed prime mover capacity of the United States to-day is so great as to place, potentially at least, at the disposal of every man, woman and child of this great country the equivalent labor of nearly 150 slaves. If labor-saving machinery may be taken as an index of civilization, and obviously it can be, we stand to-day on an economic plane vastly higher than any of our predecessors of slave-owning days.

By *time-saving* machinery is meant all that vast array of machinery that fills our factories and to a large extent tills our soil. These machines are the lineal descendants of the stone ax and other primitive tools of production. It should be noted that this class of machinery is *labor-saving* only as it is driven by labor-saving machines, such as the steam engine, water wheel, etc. Any description of this vast array of productive machinery is far beyond the limits of this paper. But it should be noted that through this machinery man has been able to multiply his productive effort many fold, and the term "mass production" properly describes our modern conception of producing the necessities and luxuries of life. No such production has ever been accomplished in the history of man and the limits to these methods are as yet not in sight.

The modern development of apparatus for transmitting intelligence is again the culmination of long-seeking effort which extends from the savage making signals with puffs of smoke down through the use of the semaphore, the heliograph, the telegraph and the telephone to the radio, in one continuous thread of development. The solution of this age-old problem is a thing to marvel at for its perfection. Obviously its greatest effect is to speed up the entire industrial machine and to add to its effectiveness.

It would be superfluous to recount the many accomplishments of applied science as represented by the work of engineering in these three fields. In transportation and communication it has almost eliminated time and space and made the whole world neighbors. It has given progressive nations physical comforts undreamed of by our ancestors and has filled their territories with the good things of life. I am not unmindful of the great progress that has been made in other fields of applied science, such as medicine and agriculture; nor of the hope that progress in these fields holds out for humanity. But nevertheless engineering is the great outstanding feature of modern civilization, and all other fields of applied science depend, perhaps, more than is usually realized upon engineering. The development of the modern printing processes alone, which are almost purely engineering in their character, has done more to disseminate knowledge in all branches of learning and has, in fact, contributed more to civilization than any other development, excepting only the steam engine.

The success of the engineer in applying science to the solution of his peculiar problems has not gone unnoted by workers in other callings. It was to be expected that correlated fields of endeavor such as industrial administration would be greatly influenced by these new methods of attack. But the engineering method has long since outgrown the bounds of the workshops and factory to such a degree that the words "engineer" and "engineering" have all but lost

their original significance. We have "efficiency engineers," "sales engineers," "human engineers" and so over a range of activity that is truly startling. Engineering, in fact, has become synonomous with accomplishing results, with "getting things done." It has become a method of thinking by which men proceed to the solution of their problems through orderly reasoned methods based, so far as possible, upon known facts; and speculative philosophies, so long the stumbling block of industrial achievement, have no place in these methods.

But more important than this, more important than the physical comforts these methods have bestowed is the manner in which modern applied science has enlarged our vision of humanity and its problems and the consequent effect upon our ideals of life on this planet. It may be logically questioned as to whether man has made *intellectual* progress since the golden days of Athens, but certainly we have widened our ideals. Or rather we have admitted among our ideals possibilities that, while recognized as desirable by our progenitors, were pushed aside because of expediency. All history indicates that men's ideals have always been limited and modified by the problems of making a living and, in general, as the tools of production have been improved and living conditions made consequently easier, more tolerant ideals have prevailed. The ancient Greeks with all their intellectual development knew of no way in which to support their intellectual life except by slavery. We, in an age when productive methods are immensely more highly developed and in a land where natural resources are ample, hold slavery to be not only unnecessary but actually unmoral. The ideals of all ancient civilizations were *ideals of necessity*. To a certain extent this is still true of our civilization. But for the first time in the history of the race there is held out a hope that through modern methods of production we may yet attain an ideal of existence that has long occupied man's mind, but because of the limitations of his industrial methods has remained a Utopian dream.

If I read the ideals of American democracy aright we are committed in this country to an effort to attain universal well-being where every man, woman and child shall have enough to eat, drink and wear, proper housing, and some measure, at least, of mental and spiritual development. And so far as can be seen at present the only hope that this can be accomplished lies in present-day engineering productive methods; and this is the reason for the faith that is in us who believe in the development of science, pure and applied, to the uttermost.

And therefore as we review the progress of engineering during the past fifty years the future is bright with hope. True, there are many difficult problems yet to be solved. We have solved in some degree the problems of production, but we have made little progress in the intelligent distribution of the proceeds of industry. But there would seem to be no reason why these difficult problems should not yield to the same rational methods of thought that have already solved some very difficult problems. It would be interesting indeed if we could lift the veil that hides the future and see what engineering will be like when Philadelphia celebrates the two hundredth anniversary of the birth of this nation that before all others holds out the hope of universal well-being.

THE ATMOSPHERE: ORIGIN AND COMPOSITION

By Dr. W. J. HUMPHREYS
U. S. WEATHER BUREAU

It will be convenient to consider first how the earth came to have an atmosphere, and after that in some detail what this atmosphere is.

To begin, then, not at the ultimate beginning, but as far back as actual knowledge permits, we believe that everything that we call matter consists of some combination or assemblage of two things as yet unresolved—the electron and the proton, the negative and the positive electric atoms, or at most, these charges and their carriers. Whether these ultimate (for the present) elements also are "matter" is, perhaps, only a question of definition. At any rate they are entities, and the most elementary of which we have any definite evidence. We have no knowledge of the origin of either the electron or the proton. They can exist separately, from which one might infer that they may have originated independently. On the other hand, the equality of their charges suggests simultaneous origin in equal numbers. But be that as it may, normally the atom of every element from hydrogen to uranium, and all their compounds from the simplest to the most complex, consist of equal numbers of electrons and protons. Even in those exceptional cases where the atom is deprived of one or more of its extra-nuclear electrons the electrons themselves are not lost but kept close by—they or others—and organic union with them re-established the instant such union is not actively prevented. Hence, wherever matter occurs in great quantity, as in a star or a planet, one may expect to find every possible combination of electron and proton, that is, all the chemical elements and also such of their compounds as the existing temperature and other conditions may favor. Doubtless, therefore, every heavenly object, however nebulous or condensed, has within itself, as certainly our own sun has, the makings of an atmosphere. Evidently, then, when the earth was pulled out of the sun by the tidal action of a passing star of much greater mass there were taken along the hydrogen, oxygen and nitrogen of the ocean and the air as well as the iron, silicon, aluminum and other elements of the lithosphere.

The portions of the sun thus pulled out by tidal action broke up, if we accept Jeffreys' logic,[1] into separate masses each of which soon became a liquid sphere surrounded by an envelope of vapors and gases. In the case of the earth, it appears that the gravity pull of the liquid sphere was sufficient to retain the water vapor, if such existed, and all the gases except hydrogen and helium.

After a relatively very short period, only a few thousand years, a more or less stable crust formed, consisting essentially of rock material, the iron and other heavy substances, through the action of gravity, having formed the inner core. The surface temperature then rapidly fell to a value comparable to that which seems to have obtained ever since, leading to the condensation

[1] H. Jeffreys, "The Earth," Cambridge University Press, 1924.

of most of the water vapor, if it existed in large quantity, and to a well-nigh perfect conservation of all atmospheric gases, including now even hydrogen and helium.

Whether this primordial supply of free air and free water vapor was great or small, we do not know. But whatever these original quantities, there was also a never-failing fresh supply of all, or practically all, the elements and compounds that constitute the atmosphere as it exists to-day, with the probable exception of oxygen. For the crusting over of the earth must have been accompanied and followed by vast lava flows and other forms of eruptions that gave off then, as they do now, great volumes of steam, carbon dioxide, nitrogen, hydrogen and other gases, except, presumably, oxygen, each of which, or its elements, had been absorbed, occluded, combined or otherwise taken up by the rocky materials while in their previous gaseous or liquid state.

Since free oxygen has not been found in volcanic gases known to be uncontaminated by admixture of atmospheric air, and since it presumably could not exist at high temperatures in the presence of free hydrogen and free sulphur, it seems that the oxygen of the air can not be of volcanic origin, at least in its present state. It may be that the original supply of oxygen was more than enough to combine with the available hydrogen and other oxidizable substances at and near the surface of the earth, and that from the beginning our world always has had an oxygen atmosphere. It is true that through photosynthesis plants give off considerable quantities of oxygen; hence the oxygen of the air might be accounted for in this way, provided plant life could have started without the presence of this gas in the free state, a result that seems quite possible, since many of the lower forms of life thrive where this element is not free, and yet under the stimulus of light evolve it from one or more of its compounds, especially water. Finally, lightning produces a little free oxygen through its action on water, and so also may ultraviolet light, but these sources appear to be insignificant.

Presumably, then, from the very beginning of its independent career the earth has had an atmosphere of nitrogen, oxygen, water vapor, carbon dioxide and various other gases. But even if they ever had been taken up wholly by other materials of the earth, which seems most unlikely, they later would have accumulated to a greater or less extent through chemical reactions, as manifested by volcanoes and biologic activities.

Now that we have seen that the earth must have an atmosphere of some kind, partly regenerated, we are sure, for we see it coming out of volcanoes, and partly primitive, perhaps, we next may inquire what the present composition of that atmosphere really is.

The oldest considerations of the air known that possibly can be called scientific are those of the ancient Greeks. They believed it to be a single, homogeneous substance, or, more exactly, an element—one of four that singly and variously combined make up all objective things. In effect, however, they declared the atmosphere to be complex; a belief implied, though perhaps not clearly recognized, in the correct assertion by Aristotle that clouds and rain are produced by condensation out of the air of aqueous vapor that previously had arisen from the surface of the earth. For more than twenty-two centuries, then, perhaps for much longer, it has been known that the atmosphere is a mixture, at least to the extent of being part water vapor and part something else; and for over two thousand years after the days of Aristotle, this is all that was known about its composition.

The first of the relatively permanent gases found to be a constituent of the atmosphere was carbon dioxide. The investigations that led to this amazing result were begun in 1751 by Joseph Black, while a student of medicine in the University of Edinburgh, and published in 1755 as his thesis for the degree of M.D. It is interesting to note in passing that Dr. Black's astonishing discovery that placed him among the scientific immortals was not anomalous, and indicative, as one might suppose, of a haphazard or even perfunctory selection of thesis topics, but a thing that incidentally evolved from a searching study of the use of alkalis and lime water in the treatment, then advocated, of urinal calculi.

The next advance in our knowledge of the composition of the atmosphere, the discovery of nitrogen, also was made by a medical student, Daniel Rutherford, in the University of Edinburgh, and published as a thesis for his degree in 1772. His investigation was begun at the suggestion of Dr. Black, the discoverer of carbon dioxide, or fixed air as he called it, then professor of chemistry at the University of Edinburgh. In the main, Rutherford first added as much phlogiston as possible to a confined volume of air, that is, burned out the oxygen, as one says to-day, but which he could not say as oxygen at that time was unknown, then absorbed the carbon dioxide, if any had been produced, with a suitable alkali, and finally examined the properties of the mephitic air—nearly pure nitrogen, as we now know—that remained. Like Black's work that led to the discovery of carbon dioxide, Rutherford's investigation also had its medical aspect. This portion of his study, however, appears to have given only negative results, for in his thesis he says: "I had intended to add something regarding the composition of mephitic air, and to seek for a reason for its unwholesome effects, but I have not been able to find out anything with certainty."

Almost immediately after Rutherford discovered the nitrogen of the atmosphere, both Scheele and Priestley found its other major constituent, oxygen; Scheele before 1773, apparently, and Priestley on August 1, 1774. Thus the priority of this discovery rests with Scheele, but, on the other hand, the priority of publication belongs to Priestley by about a year.

As early then as 1775, the atmosphere was known to consist largely, and believed to consist almost wholly, if not entirely, of (1) water vapor, recognized from antiquity; (2) fixed air, or carbon dioxide; (3) mephitic air, or nitrogen; (4) dephlogisticated air, or oxygen. Thus the problem of the composition of the atmosphere appeared to be wholly solved, and here our knowledge of it remained fixed, except in respect to a few variable impurities, for well over a hundred years, or until 1894, when Lord Rayleigh and Sir William Ramsay startled the scientific world by telling us of that strange element in the air, argon, that in total mass exceeds by several fold the whole of the water vapor, carbon dioxide and every other atmospheric constituent all combined excepting only the nitrogen and oxygen. Soon after this, and in quick succession, all the other inert gases, neon, helium, krypton and xenon, were found likewise to be interesting parts of that atmosphere which formerly we thought we knew so well. Careful analyses of the atmosphere show also the presence of free hydrogen, but the amount found, always very small, has varied so widely that its constancy is questioned. Its production by volcanoes certainly is irregular, as likewise are some of the ways by which it may be consumed. However, it seems always to be a part of the lower air; by volume seldom if ever less than one in 1,000,000, or greater than one in 5,000.

The value most frequently quoted is one in 10,000.

Finally, the air is full of electrons, radioactive gases, spores of many kinds, cosmical dust and terrestrial dust of every conceivable variety.

The volume percentage composition of dry air at the surface of the earth and freed from impurities is, approximately:

Nitrogen	78.03
Oxygen	20.99
Argon	0.9323
Carbon dioxide	0.03
Hydrogen	0.01
Neon	0.0018
Helium	0.0005
Krypton	0.0001
Xenon	0.000009

The values here given for the inert gases are by Moureu and Lepape, *C. R.*, July 19, 1926.

The amount of water vapor in the atmosphere varies widely, as every one knows, from almost nothing when the temperature is very low, to at least 5 per cent. by volume at the surface. The average amount in the whole atmosphere, however, is the equivalent, roughly, of a sheet of water 2.6 cm. deep over the entire surface of the earth.

From the above values, and various other pertinent factors, such as molecular weights, barometric pressure, distribution of temperature with height, extent and elevation of continents, etc., one can compute the approximate mass of the atmosphere as a whole and of each of its constituents. These values are given in the table following.

One of the constituents listed in this table, *viz.*, water vapor, belongs almost wholly in the lower air. This is because the vapor capacity of a given volume decreases very rapidly with temperature, and temperature in turn with increase of height. Ozone, on the other hand, is mainly in the upper air. At what height it is most abundant we do not know, but probably far beyond the highest clouds.

MASS OF THE ATMOSPHERE AND OF ITS CONSTITUENTS

Substance	Volume per cent. dry air	Total mass
Total atmosphere		51100000×10^{11} kg.
Dry air	100.00	50967400 " "
Nitrogen	78.03	38722986 " "
Oxygen	20.99	11596239 " "
Argon	0.9323	618814 " "
Water vapor		132600 " "
Carbon dioxide	0.03	21658 " "
Hydrogen	0.01	1291 " "
Neon	0.0018	689 " "
Krypton	0.0001	128 " "
Helium	0.0005	80 " "
Ozone	0.00006	30 " "
Xenon	0.000009	17 " "

Since the values in this table were more or less independently determined it could not be expected that the percentages of the constituents (not quite everything in the atmosphere) would add up exactly 100, nor that the combined mass of these several parts would be precisely the same as that of the whole. These deviations, however, are very small, indeed well within observational and experimental errors.

It is the powerful absorption band of ozone centered at around wave length .25 μ, and spreading widely on either side, that limits the ultraviolet extent of the solar radiation received at the surface of the earth. From a comparison of this limitation at different solar altitudes with each other and with ozone absorption of radiation in the laboratory, it has been estimated that if all the ozone in the atmosphere was gathered into a single layer, at standard temperature and pressure, this layer would be only about three millimeters thick. There is no strong corresponding absorption of the ultraviolet in a path of even several miles of surface air.[3] Hence we are sure that ozone is confined almost exclusively to great heights.

The percentages of the other constituents of the atmosphere remain practically constant throughout at least its

[3] R. J. Strutt, *Nature*, V. 100, p. 144, 1917.

lower ten to twelve kilometers, except as slightly altered by the rapid decrease of water vapor with increase of height. This substantial constancy of composition, despite wide variations in molecular weight, is owing to constant mixing through wind turbulence and thermal convection. But thermal convection extends to the height of only ten to twelve kilometers in middle latitudes, and to, say, fifteen kilometers in tropical regions. Beyond these levels, where temperature is practically constant with height and convectional mixing therefore impossible, the percentages of the heavier constituents except ozone decrease with increase of height, while those of the lighter increase. The ozone, it is believed, is formed by the action of radiation far in the ultraviolet on the upper levels of oxygen, hence, and because also of its slow, spontaneous decomposition, its density distribution is believed to be radically different from that of any other atmospheric gas.

The composition of the highest portions of the atmosphere, that part beyond one hundred kilometers above the surface of the earth, is very imperfectly known. One naturally would suspect an increasing percentage (not quantity, of course) of hydrogen with gain of height, but it may be that this gas is all consumed at comparatively low levels. Even if it got beyond the clouds it still would have the gantlet of ozone to run before reaching a safe level. Possibly some of the mere trace of water vapor at great heights may be dissociated by ultraviolet radiation and a little hydrogen and monatomic oxygen thus produced. We are not sure, then, whether there is or is not any hydrogen in the outer portions of the atmosphere. It is not indicated by auroral spectra, nor with certainty by the spectra of meteors. However, this is not conclusive proof of its absence, since neither meteors nor auroras reveal helium either, though surely it must be in the outer atmosphere, as it runs no chemical danger whatever, as hydrogen would, on its way thither.

Meteors tell us nothing positively about the composition of the outer air. Auroras, on the other hand, give us some very definite information on this subject. The normal base of auroras is about one hundred kilometers above the earth. Here, and for perhaps several hundred kilometers beyond, they show, by their spectra, the presence of nitrogen and of oxygen, the former by several bands, the latter through the famous "auroral line," as first explained by McLennan and Shrum,[3] of the University of Toronto.

But how, one asks, can oxygen, in adequate quantity, reach such heights? We do not know. It has been inferred from the heights at which meteors are fired that the temperature of much of the upper air must be surprisingly high,[4] equal at least to that at sea level on a hot summer day, But balloon soundings up to thirty-five kilometers or thereabouts show no evidence of such condition. Besides, the necessity for so great a density of the upper atmosphere to fire meteors as this high temperature would provide has been questioned.[5] One therefore asks whether there is any other way than through the expansion incident to high temperature by which an appreciable amount of oxygen can be got into the outer atmosphere. Possibly so. At any rate, since the auroral line appears to be due to monatomic oxygen, being a sharp line and not a band, one may suspect that the very high atmosphere contains an appreciable amount of this particular substance—a gas of but half the molecular weight of ordinary oxygen and capable therefore of reaching far greater heights. In the lower atmosphere oxy-

[3] *Proc. Roy. Soc.*, A108, p. 501, 1925.

[4] Lindemann and Dobson, *Proc. Roy. Soc.*, A102, p. 411, 1923.

[5] Sparrow, *Astrophys. Jour.*, 63, p. 90, 1926.

gen is diatomic; somewhere in the high atmosphere much of it is triatomic; and now we suspect that at still greater heights, and owing to the action on one or both of these forms, and possibly also on traces of water vapor, of excessively short wave-length insolation, it may be monatomic. Certainly the production of ozone requires the breaking down of diatomic oxygen to monatomic, some of which may, in the rare upper atmosphere, long persist unchanged.

There remains one other hint about the composition of the outer atmosphere worth mentioning, namely, its electrical conductivity, as indicated by certain wireless phenomena. This conductivity is owing, we believe, to a relatively great number of free electrons—half a million per cubic centimeter, perhaps, an enormous number, and yet small in comparison with that of the atoms present.

Our knowledge of the composition of the lower atmosphere from the surface of the earth to the height of at least fifteen to twenty kilometers, is reasonably satisfactory, except in respect to condensation nuclei and the so-called impurities; but as the upper air grows thinner, even more rapidly does our information about it become less. In many ways the state and composition of the air far beyond the highest clouds profoundly modifies not only radio communication, but even life itself, both animal and vegetable, and we earnestly want to know more about that state and that composition. Some day we shall know more about them.

THROUGH A CHEMICAL LENS

By Dr. K. GEORGE FALK

HARRIMAN RESEARCH LABORATORY, THE ROOSEVELT HOSPITAL, NEW YORK

THE life process of an individual of any species represents to the human intellect a series of changes occurring in a number of structural units, changes complex and confusing to the understanding, but in reality interwoven to produce a moving pattern which is systematic and orderly.

The various structural units undergo changes which are chemical in character. The study of these individual chemical reactions has shown that they obey the same laws and regularities and show the same relations as do the chemical reactions of so-called inanimate nature. This does not mean that all the reactions which occur in life processes are understood. In fact, the behaviors of very few can be explained satisfactorily. It does mean that the changes which permit of study are found to be chemical in the sense that the same or similar reactions outside the living organism are chemical. The realization of this fact simplifies the consideration of the chemical changes. It is not necessary to develop a new chemistry, such as a chemistry of living matter or of the changes occurring in living matter. The chemistry which has been developed in the laboratory with materials not immediately derived from living matter is all-inclusive and is sufficient for the study, consideration, classification and comparison of the chemical changes in life processes. The evidence for the simpler substances and changes is quite satisfactory. On the other hand, the direct evidence that the very complex changes follow the chemical laws developed on the basis of the simpler reactions may be incomplete in many cases, although all the evidence available points in the same direction. It will therefore be assumed that the complex as well as the simple reactions which occur in life processes obey the same chemical laws as do those outside the living organism. This statement must not be stretched to unreasonable limits. Possible chemical changes connected with thought processes, with consciousness, whatever may be meant by the term, are not included. Nothing will be said about these, because nothing is known.

The limitations of the chemical viewpoint must be realized in order to obtain a proper perspective of the ground to be surveyed. Changes in chemical compositions under various conditions are included. The substances involved may be simple or complex in composition, individuals or mixtures, colloidal or non-colloidal. But nothing is said of the structure of the living matter of which these substances form not only a part but the whole, and in which they may be said to react. This structure or form is obviously of importance in many ways. For one thing, it makes possible the recognition of the material, frequently with the unaided eye, practically in every case by the microscope.

This is not the place to enter into a detailed discussion of structure as shown by the microscope, and function as evidenced by certain chemical changes. Their relative importance, their interdependence, their reciprocal influence, merit a much more extended treatment than is possible in this connection. Just as the question of priority between the hen and the egg was settled by the biologist, so it is probable that the problem of structure and function in living organisms will ultimately be satisfactorily solved. The physical form taken by the materials to make possible the

continuance of the life process is outside the field to be discussed here. To present the matter in the form of a crude analogy, a comparison may be instituted between a university and a mausoleum. Both may have the same external structure or physical framework composed of the same materials. In the one case there is a continual activity, interchange with the outside environment, change and development of the material within the structure, and, in general, various forms of activities susceptible to quantitative measurements if the characters of the materials under examination were properly understood. In the other case, the changes occurring are few, comparatively easy to follow and simple in character. There is none of that bustling activity seen in the former case. These two sets of structures and activities may be compared to chemical changes in living and dead matter, or, to go a step farther, to changes of animate and inanimate nature. It is obviously inadvisable to extend the comparison too far, but it is desirable to form a picture of the minor importance that structure as such plays in the chemical changes in life processes as presented here.

The interpretation of life processes in terms of chemical reactions or of the changes in composition of various components, is, in the opinion of many, an object much to be desired. Such an interpretation should not only be useful because of the presentation of a different point of view in connection with certain phenomena of nature, but might add to a more fundamental understanding of the processes involved. The chemical reactions and chemical changes are necessarily an important and perhaps the predominating feature of the biological developments which are continuously occurring in active life processes.

The biological development of an individual of a given species when grossly considered represents a systematic and orderly development. Conception, birth (or initial formation of the individual), growth or development, and finally death, may be mentioned as a few of the striking events, while in between the changes occur steadily, and, with careful observation, can be followed from day to day, or during as short periods of time as may be desired. The gross changes are known to everybody with more or less exactness. The biologist follows the changes more in detail, and, on the basis of the study of the cell and its structure, has developed the science of living organisms from a structural point of view.

The question now arises as to the bearing of chemistry upon the study of the changes occurring in living organisms. The chemist considers these changes in terms of chemical reactions and changes in chemical compositions of the constituents. That is to say, the life processes of an individual, viewed by the so-called scientifically untrained man-in-the-street as a series of well-known, obvious, continuous changes in size, appearance and ability to act, by the biologist as changes in cell structures, as cell growths, as interactions between cell groups, and as coordinated interactions which culminate in the life process, will now be thought of as chemical actions and interactions of the constituents of the living organism. The life phenomena will be considered through the medium of the chemical reactions which occur. These phenomena will be watched and studied through a "chemical lens." The interpretations of the life processes in terms of chemical reactions and changes will be based upon the significance of the observations to the extent that these observations, acting as the chemical lens, will permit them to be perceived.

The chemical lens consists of the chemical changes and reactions which are studied. A chemical lens may be imperfect and not reproduce truly the object under consideration. It may be

cloudy and opaque and therefore permit only a part of the knowledge to penetrate; it may be selective in its absorption and transmission and reproduce therefore only portions of the phenomena; it may refract strongly, distort the image of the object and therefore transmit a distorted knowledge; its field of view may be very small and therefore furnish only limited and incomplete knowledge of the object under investigation. In general, the possible imperfections and troubles which are encountered with the optical lens may be paralleled by this chemical lens. If the chemical lens is so imperfect, it may well be asked why an attempt should be made to use it in the consideration of biological processes. The chemical natures of the processes involved are of the utmost significance, and while the chemical lens at the present time is admittedly imperfect it does yield results of interest and of value. A perfect chemical lens will furnish a complete representation of the chemical knowledge of the object studied as well as a perfect interpretation from the chemical point of view. This perfection of chemical lens, of representation of the object and of interpretation is obviously far from true for life processes. Some of the pictures which have been obtained with the chemical lens will be outlined.

The chemical composition is naturally the first property to be studied by means of the chemical lens. Much work of this sort has been done. The inorganic constituents of matter from various living sources have been determined, and the organic constituents have been extensively studied. The results of these chemical analyses are important and of great value. At the same time they leave a feeling of incompleteness for the consideration of living matter as such, or of the life process. The chemical lens here does not transmit enough information for a satisfactory mental image of the changes, in comparison with the living object under investigation. The reason therefore may be placed on the chemical lens. The methods of study in these cases are not sufficient to produce the clear mental image desired. It may be of interest therefore to consider these methods of study (or chemical lens) somewhat farther.

The estimation of the inorganic constituents present in living matter under various conditions and at different stages of growth has unquestionably been of value. The importance of these constituents has been made clear, and especially the significance of very small amounts of certain of the inorganic elements has been emphasized. While their importance is recognized, the ways in which they act and the parts they play in the living organisms are frequently quite obscure. The chemical lens shows that they are present, that their presence is essential for the continuance of the life processes, but only in rare cases has permitted the attainment of the knowledge of the parts they play and the manner in which they play them.

The matter is immeasurably more difficult with the organic constituents of living organisms. Many of these organic substances are inherently unstable and undergo changes in definite ways which are essential for the continuance of the life processes. In attempting to isolate these substances in the laboratory, changes may occur because of various treatments, so that the materials finally isolated may bear only slight resemblance to the substances present in the living organism. The chemical lens here has modified the substances under investigation and has changed their appearance and properties. It has been one of the aims of this branch of chemistry to improve the methods of isolation (the chemical lens in this case) so that the substances isolated may be identical with those present in the living organism (a perfect chemical lens). Much progress has been and is being made and it

may be said that the perfect chemical lens is being approached in a number of cases.

A comparison of the chemical properties and behaviors of substances of inanimate and of animate nature will serve to bring out the inadequacy of the method of chemical analysis for following the changes in the latter phenomena. The chemical analyses of mineral substances in many cases suffice to characterize them. Their states are fixed for all practical purposes, and chemical analysis at one time will show the same as chemical analysis at another time. Changes which take place in the course of time in most cases occur extremely slowly. With substances of animate nature, the time factor is of great, if not predominating, influence. Chemical analysis at any one period of the life process is important but only characterizes the material at that time. Life is kinetic, it is moving, changing, and the substances in living matter move and change. Repeated chemical analyses at different periods of the life process must be carried out. But this is not the only way in which the time element enters into the study. Because of the instability of many of the substances involved in the life process, their isolation for the purposes of identification and study will be accompanied by changes. Many of the substances present in animate nature are not as stable as most of those present in inanimate nature, and methods of chemical analysis must take account of this fact. The chemical lens through which many facts of the mineral world are observed satisfactorily is not sufficient for many facts of the world of living matter. For example, the phenomena of substances in the colloidal state need new or modified methods of study or a more complete chemical lens.

It is evident that it is extremely difficult to develop a chemical picture of the whole of a life process. A chemical analogue of the life process is to seek. In the past six years Miss Helen Miller Noyes and the writer have been developing a line of work at the Harriman Research Laboratory which may perhaps be accepted as a contribution to this study. A new type of chemical lens has been developed, and the results of the study of the chemical properties by this method when compared with some of the results of biological study may be of interest and permit of further developments. Only an outline of this method can be presented here; for details the communications presented elsewhere must be consulted.

The chemical changes during the life process in any one form of living matter proceed in certain definite ways peculiar to that form of living matter, although many other changes in the material are possible. The directive agencies are assumed to be "enzymes," substances which, while not as yet isolated in a pure state or as definite compounds, take part in the reactions of living organisms with the result that products are produced necessary for the continuance of the given life process. Preparations from living matter are able in the laboratory to produce definite chemical changes in complex substances as well as to bring about chemical reactions in simpler substances. This fact proves that enzymes and enzyme actions are not mere abstractions invented for the purpose of mentally accounting for certain changes occurring in the course of life. It may well be possible to go to the other extreme and to consider that enzymes and enzyme actions are the chemical essentials of life processes. A study of enzyme actions may therefore furnish a more useful chemical lens, in the sense of approximating more closely than other chemical methods which have been used the actual changes and behaviors of living matter.

Without entering into the details of the work at the Harriman Research Lab-

oratory, a few of the general principles developed may be given. It was realized that the chemical changes brought about by preparations from living matter (containing enzymes) could not in general be the same as those changes which occur in the living organism. Simple chemical changes were therefore chosen for the *in vitro* tests, changes which, while perhaps only remotely connected with changes in living organisms, nevertheless might be expected to show a number of the different enzyme actions of the organisms or at least to parallel them. Conditions of testing which modified the materials as little as possible were developed. Various normal tissues and tumors from a number of different animals were studied.

After testing various enzyme actions of the materials, the hydrolytic actions on a number of different esters (ten) under fixed and comparable conditions were chosen as most useful and satisfactory. It was recognized early that the actual amounts of the enzyme actions were not the most important factors in the study, although these were interesting and at times useful. Rather, the comparative hydrolytic actions of a given material on the different esters, expressed most readily in terms of percentages of the largest action of that series, were found to be most significant. A method of plotting the results was developed which permitted the presentation in the form of a curve of ten (or any number) of these ester-hydrolyzing actions of any one tissue and the comparison of this curve with the curves of other tissues. These curves or "pictures" of relative enzyme actions were significant of certain tissues and tumors. Frequently, where the absolute action of a given tissue from different animals of a species varied greatly, the curves of the relative actions were found to coincide closely.

The results obtained by means of this chemical lens in a number of cases paralleled the views obtained by other methods of study; in other cases apparently led to opposite conclusions. One example of the latter will be given. In the study of tumors, both from animal and human sources, the chemical enzyme study (chemical lens) showed that various tumors from different sources which histologically were found to be quite different, gave the same curves of relative enzyme actions, while on the other hand, a number of tumors which were the same histologically gave entirely different enzyme curves.

It is obviously impossible to say that either of these methods of investigation is wrong. The histological results are based upon long years of study and have proved most useful in many ways, but it can not be said that they are complete or final. The enzyme method of study is a comparatively recent development and it is perhaps too early to discuss the exact significance of the results. The chemical lens in this case is still too new to make possible a statement of the field which it covers, the light which it transmits, and its possible imperfections. It may be said, however, that it appears to offer an additional method of study of life processes, and perhaps approach more closely from a chemical standpoint the properties and changes which occur in living organisms.

MONGOLIAN MAMMALS OF THE "AGE OF REPTILES"

By Professor WILLIAM K. GREGORY

AMERICAN MUSEUM OF NATURAL HISTORY

THE discovery of dinosaur eggs in Mongolia by the Third Asiatic Expedition of the American Museum of Natural History seemed to capture the imagination of the world and jokes about the price of ancient dinosaur eggs per dozen became every man's pleasantry. But the discovery of six imperfectly preserved fossil skulls of small mammals in the very same beds that yielded the dinosaur eggs was an event of exceptional importance only to the very few. Undoubtedly the most far-reaching result of the entire expedition has been the opening up of the geological record of a new world to geologists, but on the paleontological side of the expedition the Cretaceous mammal skulls are perhaps the most valuable fossils so far discovered.

The swarming dinosaurs of the Cretaceous age in Mongolia probably paid little attention to the "wee timorous beasties" with pointed snouts and furry coats that scampered around under their feet. With no one to warn them of the dangers of letting in a horde of immigrants that would eventually crowd them off the earth, the dinosaurs went

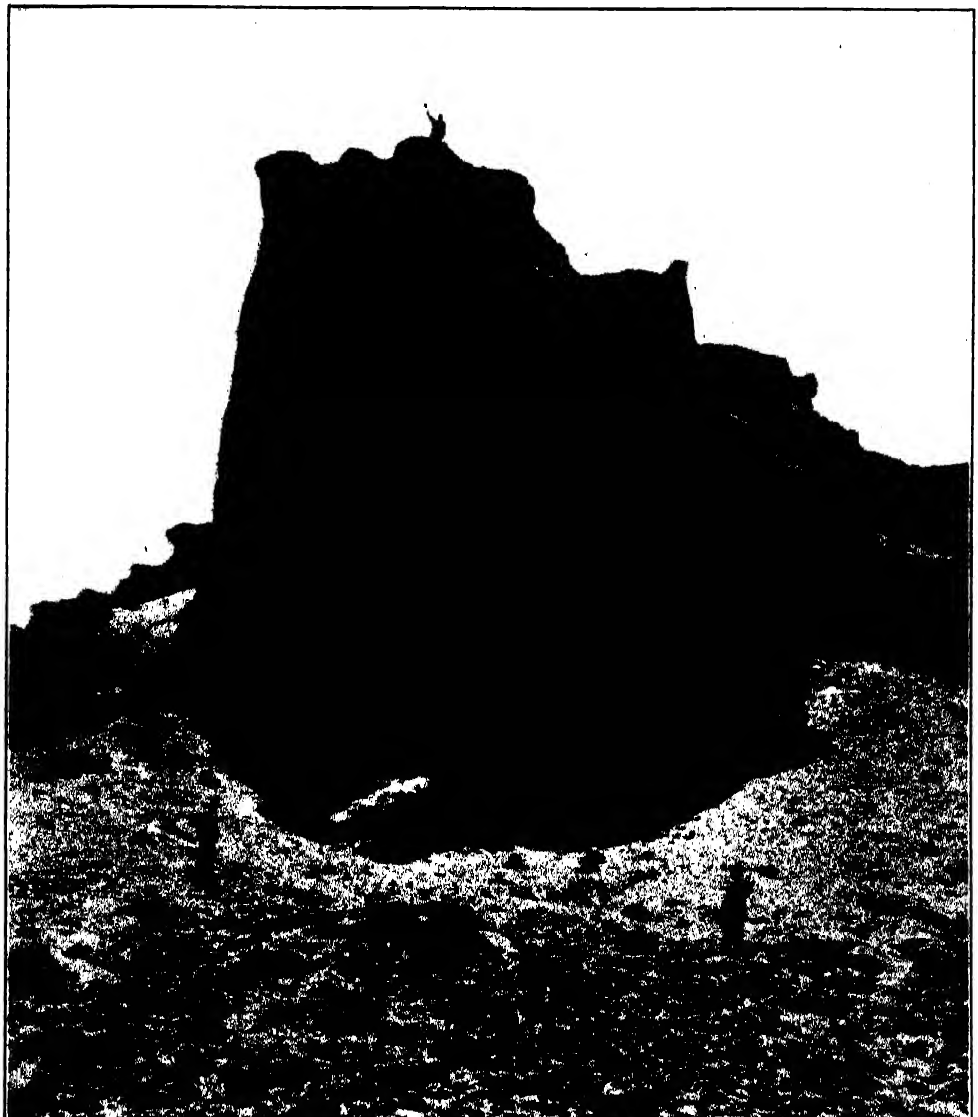
Photograph by American Museum of Natural History

FIG. 1. A "MISSING LINK"

FROM THE CRETACEOUS AGE OF MONGOLIA. WALTER GRANGER HOLDING ONE OF THE SIX PRICELESS SKULLS OF PLACENTAL MAMMALS OF THE DINOSAUR AGE FOUND BY HIM NEAR THE FLAMING CLIFFS AT SHABARAKH USU IN THE GOBI DESERT.

Photograph by American Museum of Natural History

PLATE I. CAMEL CARAVAN OF ONE HUNDRED AND TWENTY-FIVE CAMELS
AT THE BASE OF THE FLAMING CLIFFS AT SHABARAKH USU.



Photograph by American Museum of Natural History

PLATE II. ONE OF THE SANDSTONE CLIFFS AT SHABARAKH USU

on playing the game of life in the good old way and the immigrants did the same. For many hundreds of thousands of years the dinosaurs muddled through, but near the close of the Cretaceous age their doom was sealed and they disappeared from the earth in Mongolia as well as elsewhere. Thus the mighty were put down and the meek inherited the earth.

Numerous reasons have been alleged for this momentous event. Some have suggested that the little mammals broke into the dinosaurs' eggs and ate the contents. Others hold that in the long run the mammals came through because of their superior equipment for resisting severe changes in temperature; because of their improved locomotor apparatus, better brains and far less wasteful methods of reproduction. Be that as it may, the Cretaceous mammal skulls discovered by Walter Granger and his party at the Flaming Cliffs at Shabarakh Usu in the Gobi Desert have proved to be veritable missing links in the story of mammalian evolution. As might have been expected from previous evidence, the placental, or higher mammalian stock, even in Cretaceous times had already split up into various distinct lines. Hence it is not surprising that even in the five Cretaceous placental mammal skulls found in one locality in Mongolia we have representatives of four genera and two distinct families. The more insectivorous-like forms (Fig. 2, above) in some ways suggest the tenrecs or centetoid insectivores of Madagascar, but both their skull characters and their dentition are definitely less specialized than in their modern relatives. The members of the second family (Fig. 2, below) are distinctly more carnivorous in the general form of the skull and dentition and they combine characters of the carnivorous-insectivorous marsupials with others seen

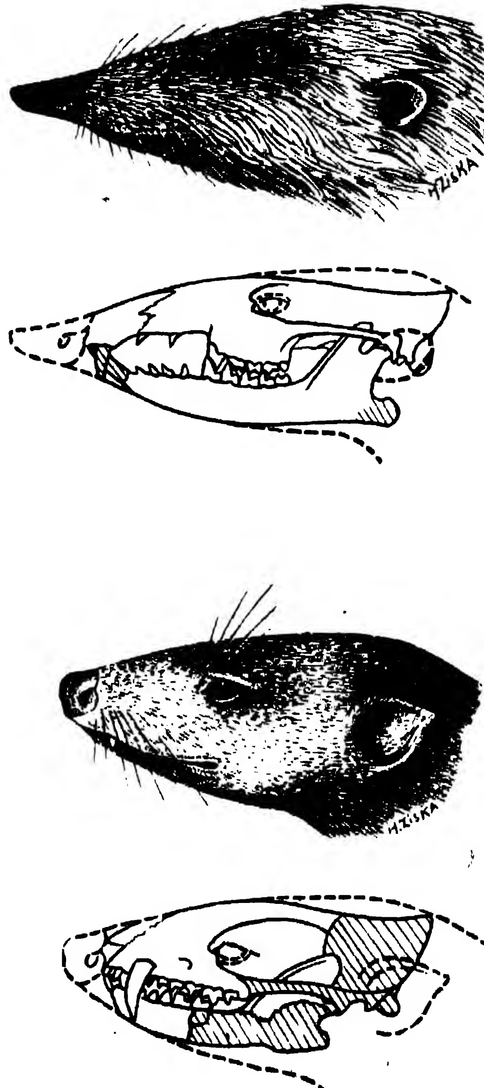
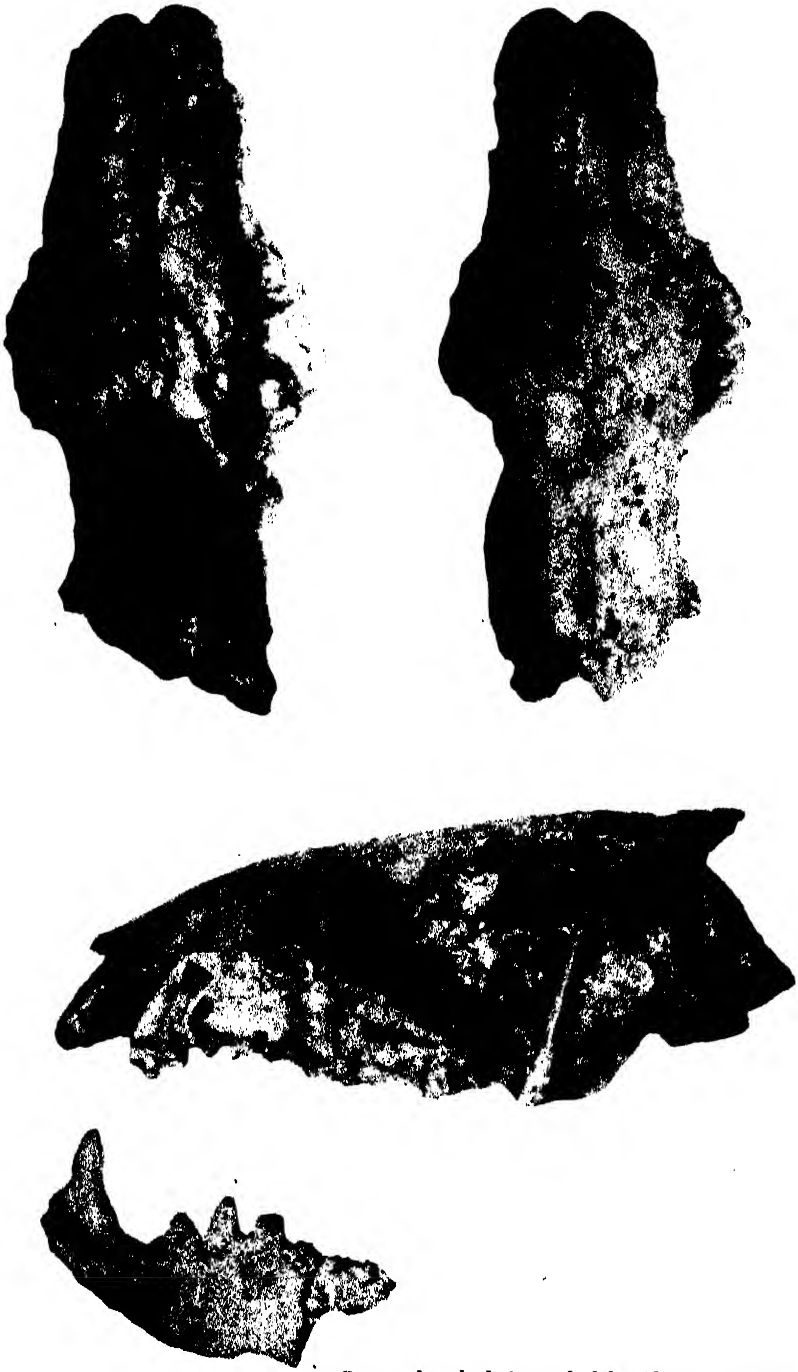


FIG. 2. SKULLS AND RESTORED HEADS OF THE MONGOLIAN CRETACEOUS PLACENTAL MAMMALS

NATURAL SIZE. ABOVE, THE "INSECTIVORE" (*Zalambdalestes lechei*). BELOW, THE "LITTLE CARNIVORE" (*Deltatheridium pretrituberculare*).

among the earliest creodonts or primitive placental carnivores of the Eocene age of North America. In both families the braincase is distinctly smaller than in modern insectivores or marsupials of the same size.



Prepared and photographed by Albert Thomson

FIG. 3. THE "LITTLE CARNIVORE" SKULL (*DELTATHERIDIUM*)
ABOUT THREE TIMES NATURAL SIZE.

Prepared and photographed by Albert Thomson

FIG. 4. ANOTHER OF THE "LITTLE CARNIVORES," PALATE AND LOWER JAW
ABOUT THREE TIMES NATURAL SIZE.

Huxley, Henry Fairfield Osborn and other paleontologists had already inferred that the remote ancestors of the higher or placental mammals in Cretaceous times were small forms of insectivorous-carnivorous habit, but prior to the Mongolian find the Cretaceous forerunners of the swarming placental mammals of early Eocene times were practically unknown except by a few scattered teeth from the Upper Cretaceous of North America of very doubtful affinities. After these priceless skulls had been very skilfully freed from the matrix by Albert Thomson, of the American Museum's technical staff, Drs. Andrews, Osborn and Matthew generously assigned them for study and description to the present writer, who in turn invited Dr. George G. Simpson, of Yale University, to collaborate in this study on account of his thorough knowledge of the Cretaceous and Jurassic mammal teeth secured long ago by Professor Marsh. Our observations, published in the American Museum Novitates and in the *American Journal of Physical Anthropology*, supply the evidence for the conclusion that even in the Lower Cretaceous the mammals as a class were already far from the beginning of their career and had already separated into Marsupials and Placentals, as well as an older side branch called Multituberculates. Secondly, the Mongolian skulls tend to confirm the view of Huxley and Osborn already noted, that the remote ancestors of the higher or placental mammals were insectivorous-carnivorous in habit, since the teeth in these fossils present significant resemblances to those of existing insectivores.

Another expectation or prophecy that these invaluable specimens support relates to an early stage in the evolution of the famous "tritubercular" type of molar tooth. Cope, Osborn, Matthew and others have produced cumulative evidence for the view that even the most diversified types of upper molar teeth among the later placental mammals may all be traced backward along gradually converging lines to a central type, a triangular form with three principal cusps, the apex of the triangle being on the inner or palatal side of the upper molars. This great generalization, one of the best established in the whole field of vertebrate paleontology, has unfortunately been obscured in the minds of many writers on human dental evolution by the more difficult question of the remote origin of the tritubercular type itself. Cope and Osborn held that the triangle in the primitive mammalian molars in turn arose from the folding up of a triad of cusps that were originally in a straight line (Fig. 7, I), in such a way that in the upper molars the larger central cusp shifted to the inner side of the tooth. Moreover, Osborn held that in the premolar teeth the original main cusp remained on the outer side of the tooth. Thus according to this view, the premolars and molars were essentially different as regards the origin of their crown pattern, no matter how much they might come to resemble each other in the later course of evolution.

Wortman, Gidley and the present writer, on the other hand, maintained that there had been no such shifting of the main original cusp in opposite directions in the premolars and molars, but that the low cusp on the inner side of the upper molars was not the displaced "original tip" or first cusp but, just as in the premolars, it was a spur or inward growth from the base of the crown, the original cusp remaining either in the center or near the outer side of the tooth (Fig. 7, II). According to the present writer's theory there should once have been a stage in which the two outer cusps of the triangle were not yet separated from each other, and in which the

Prepared and photographed by Albert Thomson

FIG. 5. THE "LITTLE INSECTIVORE" SKULL (*ZALAMBDALESTES LECHEI*)

FIG. 6. DIVERGENT EVOLUTION OF UPPER MOLARS INTO SHEARING AND GRINDING TYPES

IN THE "LITTLE CARNIVORE" OF THE MONGOLIAN CRETACEOUS (NO. 2) THE UPPER MOLARS ARE OF THE "PRETRITUBERCULAR" TYPE. THE SHEARING SERIES AT THE LEFT IS BASED ON SUCCESSIVE STRUCTURAL STAGES IN THE SECTORIAL UPPER MOLAR OF EXTINCT CARNIVORES OF THE HYAENODONT FAMILY. AFTER OSBORN, MATTHEW AND GREGORY. THE GRINDING SERIES AT THE RIGHT IS BASED CHIEFLY ON SUCCESSIVE STRUCTURAL STAGES IN THE GRINDING UPPER MOLAR OF THE HORSE (10, 11, 12).

inner cusp had the appearance of a low process or heel. Exactly such a stage is supplied by the molars of several of the Cretaceous mammal skulls from Mongolia (Fig. 6, 2).

With regard to the lower molars, the adherents of both these rival interpretations were in agreement that, whatever the remote origin of the lower molars may have been, there was an early stage in which the primitive lower molar crown consisted of two distinct parts, the front part comprising a triangle of three sharp cusps, the back part consist-

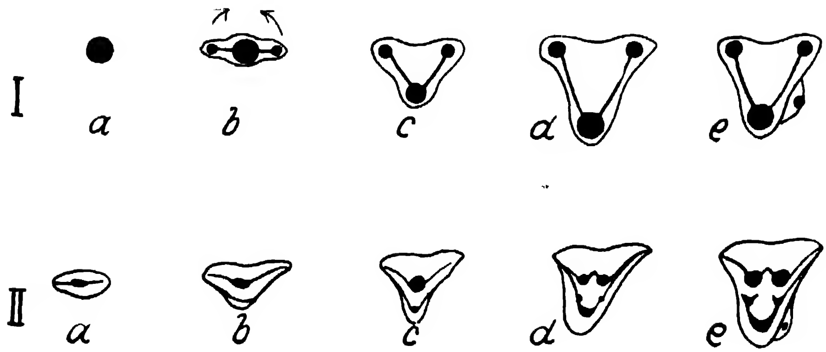


FIG. 7. OPPOSING VIEWS OF THE ORIGIN OF THE TRITUBERCULAR UPPER MOLAR OF PRIMITIVE PLACENTAL MAMMALS

I. THE COPE-OSBORN THEORY. II. THE AUTHOR'S THEORY; *a, b, c, d, e,* SUCCESSIVE STAGES.

ing of a low projection or heel. In the later mammals the back part or heel is very often wider transversely than the front part or triangle, and when this is so, the large cusp on the outer side of the heel of the lower molar fits between and on the inner side of the two well-separated outer cusps of the upper molar. It was predicted by the present writer that the "pre-tritubercular" molars of placental mammals should have the heel of the lower molars narrow transversely and the main outer cusps of the upper molars not yet separated from each other. Several of the Mongolian Cretaceous mammals remain in this stage of evolution and thus tend to fulfil the prophecy, while others have already advanced toward the more typical later stage of evolution with nearly separate outer cusps in the upper molars and relatively wider heels on the lower molars. This indicates that still earlier stages of molar evolution must be sought in formations older than the Djadokhta formation (Cretaceous) of Mongolia. And these earlier stages, long known from the Upper Jurassic of Wyoming and Great Britain and long since described by Owen, Osborn and Marsh, are

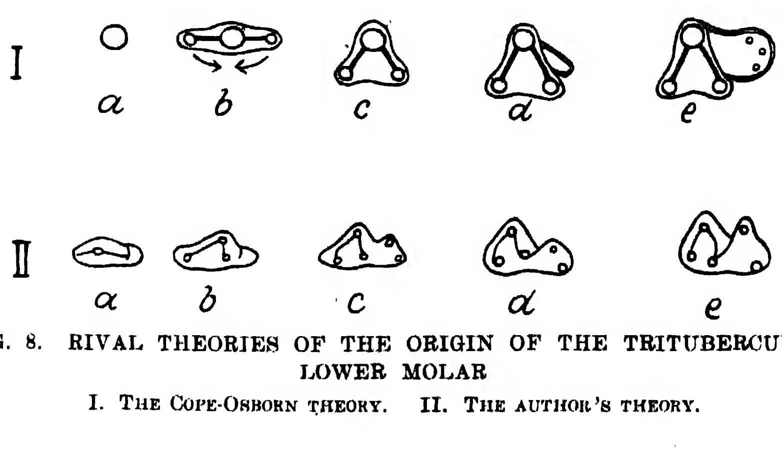


FIG. 8. RIVAL THEORIES OF THE ORIGIN OF THE TRITUBERCULAR LOWER MOLAR

I. THE COPE-OSBORN THEORY. II. THE AUTHOR'S THEORY.

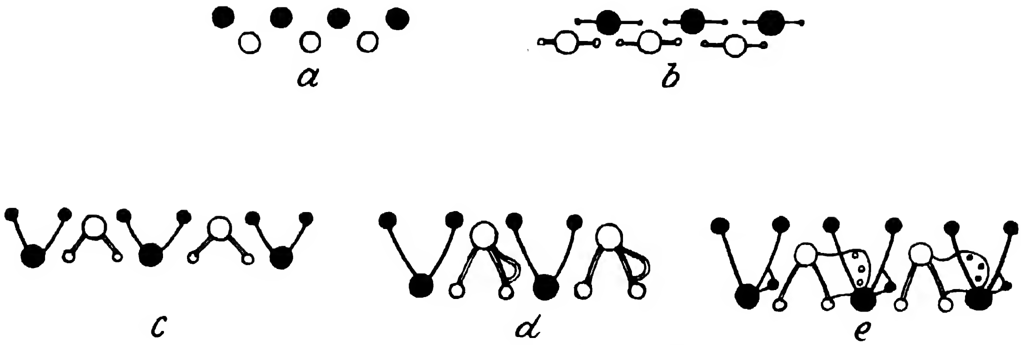


FIG. 9. THE COPE-OSBORN THEORY

OF THE EVOLUTION OF OCCLUSION OR INTERLOCKING RELATIONS BETWEEN THE UPPER MOLARS (BLACK DOTS) AND THE LOWER MOLARS (WHITE DOTS).

now being critically and very successfully restudied by Dr. G. G. Simpson, of Yale University.

The Mongolian placental mammal skulls thus tend to bridge the gap in time and in evolutionary stage between the known Jurassic mammals on the one hand and the Eocene mammals on the other. To this extent therefore they may be regarded as "missing links" in the evolutionary pedigree of the later mammals, including man.

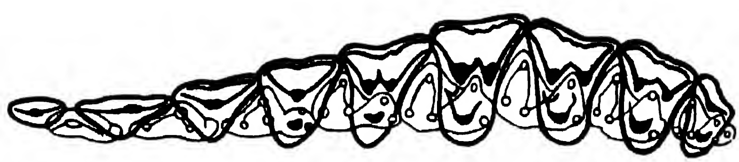


FIG. 10. AUTHOR'S THEORY

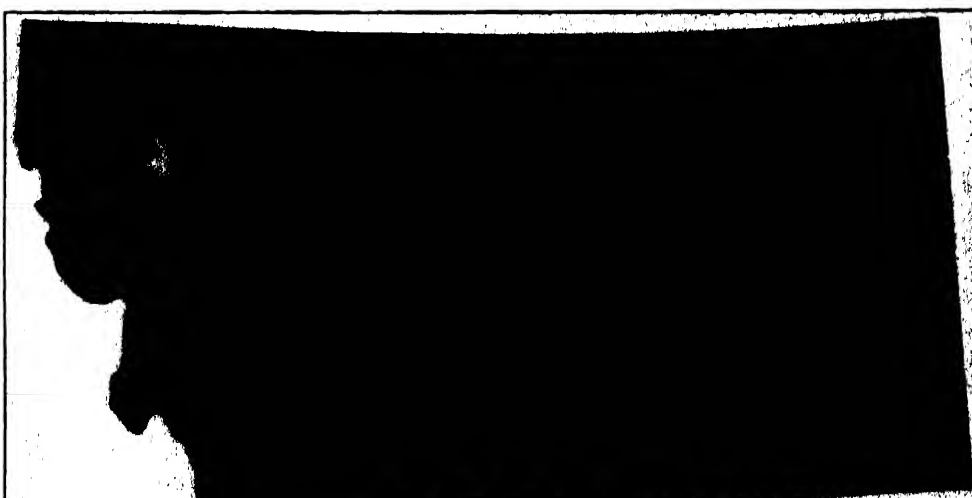
OF THE EVOLUTION OF OCCLUSAL RELATIONS OF UPPER AND LOWER TEETH. SUCCESSIVE STAGES OF COMPLICATION SEEN FROM LEFT TO RIGHT.

BOTANICAL EXPLORATIONS IN THE ROCKY MOUNTAINS

By Professor J. E. KIRKWOOD
STATE UNIVERSITY OF MONTANA

The Flathead River drains the western slope of the Montana Rockies between latitudes 47° 20′ and 49°. Above Flathead Lake it divides into three branches, the North, Middle and South forks. The North Fork lies along the western side of Glacier National Park and has been easily accessible by wagon road for many years. The Middle Fork is followed through much of its course by the Great Northern Railway. The South Fork, however, with its numerous tributaries, traverses an isolated and little known region, a remote wilderness, approximately fifteen hundred square miles in extent. The stream flows in a northwesterly direction over one hundred and fifty miles and finally swings westward and joins the other branches near Columbia Falls. It is fed from the east by streams rising under the very crest of the Continental Divide and from the west by branches from the Swan Range. The floor of the valley lies mostly above 3,500 feet but peaks along the limiting water sheds rise to altitudes of 9,000 feet, or more. The topography is rugged and picturesque, rising in towering cliffs or precipitous slopes of stratified rocks of ancient, mostly proterozoic age.

There is no record of which the writer is aware of any botanical collections or observations of this valley except about its mouth, where a few collections have been made. The whole interior valley is entirely virgin territory, which induced the author to spend some time in the



MAP OF MONTANA

AREA COVERED OUTLINED AND SHADED. · BY PERMISSION OF RAND, MCNALLY AND CO.

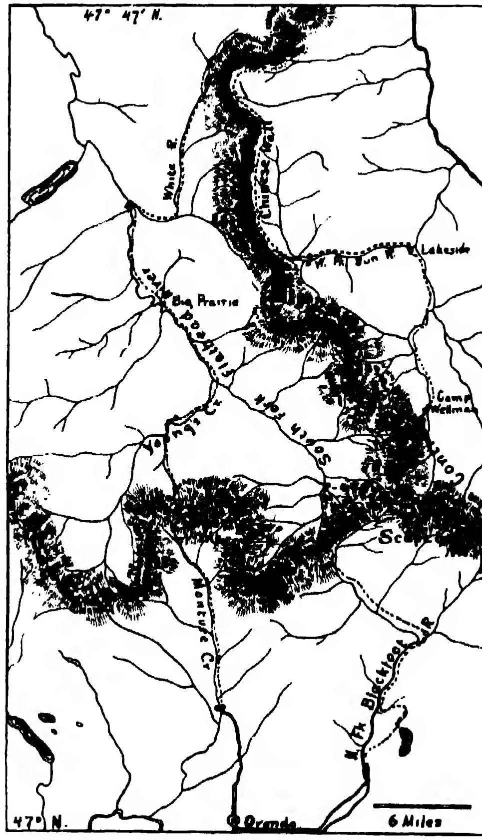
summer of 1925 in the effort to make a brief reconnaissance of its flora. Although only about seventeen days were available and the trip somewhat hurried, a fair impression was obtained of the vegetation in its composition and distribution. The season was far advanced, but a representative collection was made, which with notes and photographs will form a permanent record of the observations.

Combining geological and botanical objectives, our party included President C. H. Clapp and Professor J. H. Bradley, geologists, and Mr. J. H. Ramskill and the writer, representing the botanical interests, all of the State University of Montana. Besides these were Mr. Burr Lennes, attracted by the recreational opportunity, Joseph Murphy, Virgil Woods and Gilbert Muchmore, packers, and William Burns, cook.

Supplies and equipment having been shipped from Missoula by truck some days previously we left town on the morning of August 23. The first lap of our journey took us by auto over a good road along the Blackfoot River, a distance of nearly sixty miles, to the village of Ovando, situated in a broad basin marked by numerous small drumlins and moraines of glacial gravels. At this place the Weather Bureau records show that the last killing frost of the season occurs in July and the first in August. The altitude is 4,100 feet.

From Ovando we proceeded north to a point on Monture Creek, where our packers had assembled the outfit, consisting of twenty-two horses and the usual camping paraphernalia and supplies. Here we left the auto for the saddle. The packs were made up and preparations completed for an early start the next morning.

Monture Canyon is the main southern gateway into the South Fork country. It heads upon the divide separating the waters of the Flathead and the Blackfoot. Our course lay up this canyon toward high summits visible from far out in the Blackfoot valley.



MAP OF AREA TRAVERSED ON THE TRIP

Route indicated over main range of the Rockies and parts of the Columbia and Missouri drainage.

We broke camp in the morning under a dull and leaden sky. Rain had fallen during the night and threatened all day. Clouds hung low and the neighboring crests shone with the gleam of newly fallen snow. The wind blew chill and raw and the nodding flowers along the trail seemed out of place in the wintry scene.

On leaving the plain the first species met are the widely distributed yellow

SOUTH FORK OF THE FLATHEAD AT BIG PRAIRIE

NEAR THE SUMMIT OF THE DISTANT PEAK IS SHOWN A BED OF LIMESTONE SANDWICHED IN THE SPOKANE FORMATION.

pine (*P. ponderosa*) and the Douglas spruce (*Pseudotsuga taxifolia*) which in all this region form the marginal forest growth at the tension line between woodland and prairie. On steep slopes, however, it is only a fringe and soon becomes mixed with and then replaced by the lodgepole (*Pinus contorta*), sometimes with a liberal addition of western larch (*Larix occidentalis*). Engelmann spruce (*Picea engelmanni*) and the sub-alpine fir (*Abies lasiocarpa*) begin to appear in the narrow gulches and grow increasingly abundant until they become dominant in many places above 5,000 feet, where the white bark pine (*P. albicaulis*) mingles with them in increasing numbers up to the limit of tree growth.

Gradually the stream at our left dwindled to a mere brook and divided into numerous feeders emerging from narrow gulches slanting into the main canyon. We were nearing the pass. Ahead of us loomed walls of crumbling shale, their deep strata of red and green argillite showing through the scant vegetation. The Spokane formation with its strongly ripple-marked deposits is conspicuous through all these mountains. At last we topped the summit at 6,600 feet and began the descent into the Flathead drainage. The trail dropped rapidly now to Hahn Creek, a small stream, at a point on which a mile or more from the pass we had agreed to make camp. We were now in the green timber and along the stream below us appeared frequent open grassy glades, inviting after the first day's ride of twenty miles. The sun was now shining and the sky clear as we pulled into Bear Slide Camp at mid-afternoon.

The sun set early behind a high ridge and with the shadows a chill settled in the canyon and before morning grew into a heavy hoarfrost. "Virg" and "Gil" pitched the tepee and before its entrance built a roaring fire, around which we sat and talked while the thin crescent of the new moon sank to early rest behind the hills. Finally we sought our blankets in the firelight's fading glow and were soon lost to sense of camp and trail.

With the first gray streaks of dawn the men were astir, the cook's fire was crackling, bacon was sizzling and in an incredibly short space the call, "Come and get it," rang out. Some whose more sensitive ears had caught the first sounds of the day's business had washed in the ice-cold stream and dressed with promptitude and now lined up to a breakfast of oatmeal, bacon and eggs and potatoes with steaming hot coffee, while the more tardy members made hurried dashes to complete the morning's toilet and appear at the board before it was too late.

It remained now to roll our bedding and prepare for the day's march. Everything must again be compactly stowed and prepared for the packing. Ordinarily the horses have been rounded up before breakfast and now while the cook is washing the dishes and putting his stuff away, horses are being saddled, the tents come down and we are again on the trail before the sun has fairly risen on the landscape. On this occasion Mr. Ramskill and the writer elected to remain behind and work the local vegetation while the rest of the party proceeded to the next camp on Young's Creek, some seven miles below.

Moser Mountain rises abruptly from its base on Hahn Creek to an altitude of 8,530 feet. Much of its slope stands at an angle of forty-five degrees, with here and there precipitous walls or more gentle acclivities. Several places on its western face are bared by snow slides. One of these rises from our camp site about two hundred yards wide to a distance of a quarter of a mile or more from which every vestige of forest has been swept away. The deep, accumulated snows, loosened as thawing begins, break loose and rush down with tre-

FOLLOWING THE CONTINENTAL DIVIDE
THE PACK TRAIN ON BENCHMARK MOUNTAIN.

mendous force. The foot of such slides is usually marked by a tangled mass of splintered, broken trees intermingled with rocks and earth. Here, however, the debris has disappeared by fire or decay and the frequent recurrence of the avalanches keeps the forest from gaining a foothold. Upon ascending over this bare slope it seemed remarkable that snows could accumulate upon it, so steep and insecure was the footing which we experienced. Short sod-forming grasses and sedges alternating with patches of bare rock or low thickets of alder (*Alnus sinuata*) constituted the ground cover. Occasional gullies occupied by trickling streams are fringed with species of *Saxifraga, Arnica, Senecio, Campanula* and *Osmorrhiza* in good flowering condition at 7,000 feet. Above the slide, the slope bears a sparse forest with meager undergrowth, so that little difficulty was experienced in passing through. Here as elsewhere in the region at similar altitudes, the open forest is carpeted with a sod of the wood rush (*Juncoides glabratum*). Below 7,000 feet, on a warm and dry exposure, yellow pine, Douglas spruce, Rocky Mountain juniper (*Juniperus scopulorum*) and patches of creeping juniper (*J. Sabina*) were found. At all elevations, more or less, but especially at higher points and on the very summit, we found the dwarf juniper (*J. communis*) in spreading procumbent shrubs. The forest of the upper slopes is almost pure white bark pine and reaches to within one hundred yards of the summit. Here massive rocks tumbled one upon another bear only a thin crust of lichens or in a few favored places a sod of *Saxifraga austromontana*. The top is a narrow space, mostly of smooth rock or shingle, but a pile of coarse rock fragments yielded specimens of *Rubus* and *Ribes* a foot in height, their tops beaten back to the level of the surrounding stones.

What stirred us most, however, as we gained the summit and looked beyond into a broad basin two or three hundred feet below, with a northeastern exposure, was a fine little stand of Lyall's larch (*Larix Lyallii*), that rare and interesting species which is seldom found below 8,000 feet in this latitude and which, while partial to sheltered spots, still ascends to greater altitudes than any other of our forest trees.

Our time was short, but we paused to enjoy the magnificent panorama spread out before us. The rugged grandeur of the wilderness in lofty peaks and deep dark canyons extended far toward all points of the compass; the Swan Range to the west and beyond them a glimpse of the Mission Mountains, to the east not so far away the Continental Divide rose as a huge barrier with its high points of Sugarloaf and Scapegoat, and far away to the north in the blue haze of the horizon peak followed peak until the serrated skyline was lost in the distance. Regretfully we turned our backs upon the scene and began the descent. Considerable care had to be exercised in avoiding dangerous footing and in finding our way around the precipitous walls, less evident in the downward than in the upward progress.

The trail down Hahn Creek leads through a heavy forest of pine, spruce and fir. The stream flows through a narrow gulch with high and steep slopes on either side enhancing the deep shade, and after two hours riding through this defile we were glad to emerge into the wider valley of Young's Creek, a stream about fifty feet in width at the ford where the water came to the horses' knees. The bottom at this point, about half a mile in width, is scantily covered with lodgepole pine or treeless, except for the thicket of alders, willows and

FOX'S CABIN IN THE SOUTH FORK VALLEY

AN EARTH ROOF BEARING A CROP OF PLANTS. TREES ARE LODGEPOLE PINE (*Pinus contorta*).

THE CAMP AT BIG PRAIRIE

FOREST OF YELLOW PINE AND WESTERN LARCH IN THE BACKGROUND.

cottonwood that fringes the creek. A mile or two beyond the ford brought us to the camp in a grove beside the stream.

The day was far spent, but we still had an hour or more before dinner and plenty of work to fill it. The collections had to be put away and the field notes written up. Often this work carried over into the candle light. Every day brought its additions and the accumulation of material in the presses required attention. Most of our collections were made along the trail from early morning until mid-afternoon or later, with an average march of fifteen miles a day. As the trails traverse varying soil conditions, exposures and altitudes the record of the plant life as seen on either hand affords a sort of huge belt transect crossing mountain ranges and valleys. Considering the large area of the new territory and the short time available a passing view of the vegetation was preferred to a more intensive study of a small locality.

The next stage of the journey took us twelve miles to Big Prairie. Big Prairie is a treeless flat several square miles in extent lying in the broad valley of the river. Here and there groves of yellow pine and the lodgepole forest encroach upon its margins. Along the river are found western larch, Engelmann spruce and Rocky Mountain juniper. The prairie, with its bunch grass, sagebrush and shrubby cinquefoil (*Dasiphora fruticosa*), is distinctly arid transition, while the Canadian zone is represented by the lodgepole and spruce. The snowberry (*Symphoricarpos racemosa*) and *Rhamnus alnifolia* are plentifully represented. The floor of the valley breaks

abruptly in steep slopes which rise in rugged walls to elevations of 7,000 feet or more, heavily wooded from the base. The east and north exposures are especially favored, where lichens (*Peltigera* and *Cladonias*) abound in the forest duff and rattlesnake plantain (*Peramium menziesii*) and *Pedicularis racemosa* are plentiful.

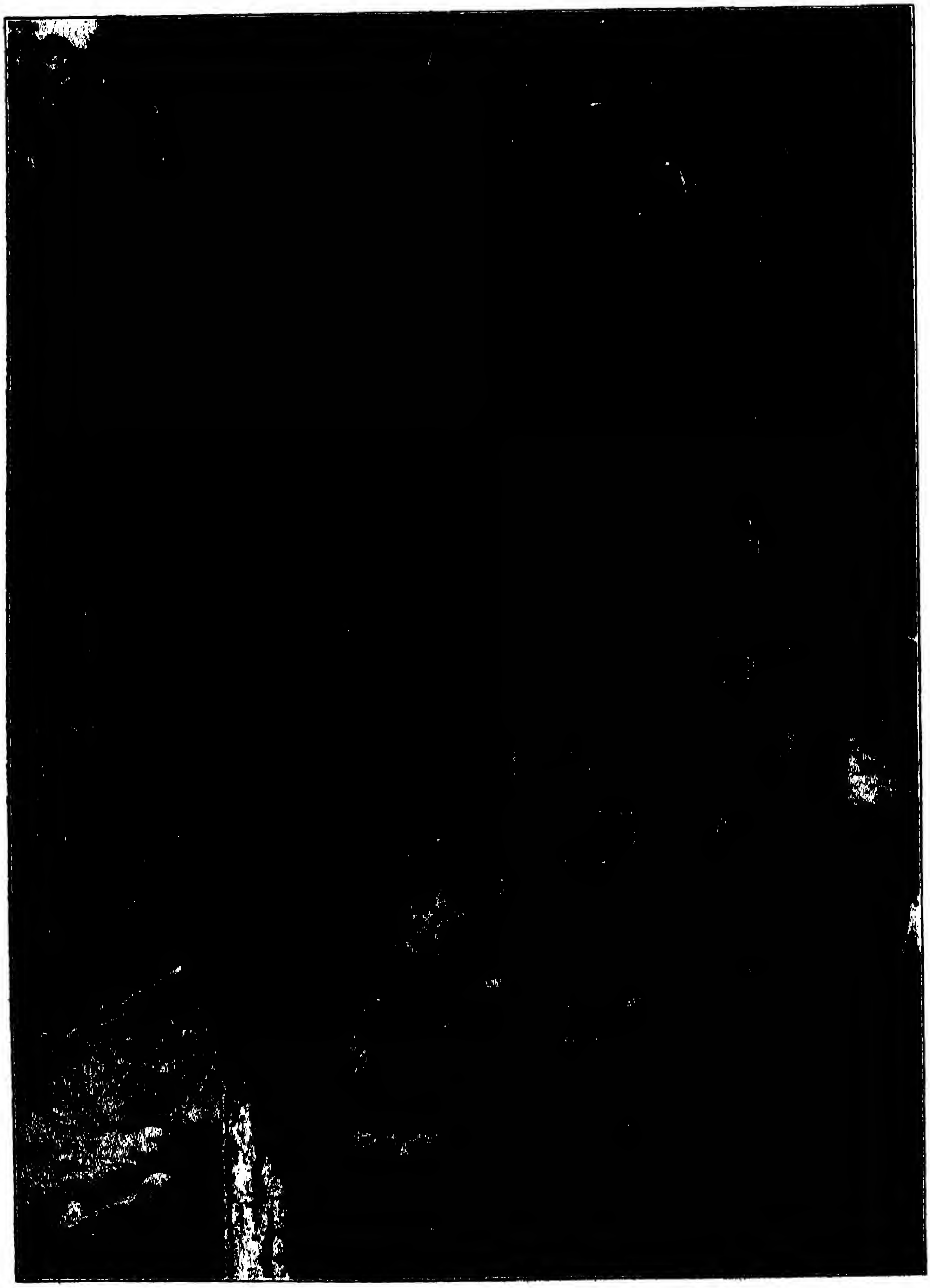
Like all streams of this mountain region the South Fork of the Flathead pursues its way over rock ledges, sand bars and beds of gravel and boulders. At Big Prairie it is sixty to one hundred feet in width, shallow, but crystal clear in the deepest pools, abounding in beautiful trout. The black cottonwood (*Populus trichocarpa*) is the principal deciduous tree of the banks along with numerous shrubby willows. Thickets of cornel (*Cornus stolonifera*) are frequent. Herbaceous life along the gravel-strewn shore includes an onion (*Allium sibiricum*), low fireweed (*Chamaenerion subdentatum*), *Galium boreale* and mint (*Mentha canadensis*) in vigorous flowering condition.

At Big Prairie, according to previous arrangement, the party divided. The botanical contingent, with two packers, Murphy and Muchmore, and ten horses proceeded on a more extended trip, while the geologists elected to explore for fossils the Devonian and Mississippian deposits of the neighborhood. Accordingly after a couple of days at Big Prairie we pulled out northward, with the mouth of White River as our first objective. White River enters the South Fork from the east, but most of its course is parallel with the other stream flowing southward in the heart of a great syncline until, about seven miles from its mouth, it swings directly west to a junction with the South Fork. The white limestone gravels of its broad bed are conspicuous and when viewed from a high lookout are traced with ease for a great distance.

One of the notable plants of the broad gravel bars and sand flats were the frequent mats of *Dryas octopetala*, now mostly past its fruiting stage. Meadows and swamp areas in this locality yielded the best collections of *Aster, Erigeron, Agoseris, Heracleum, Angelica* and other genera. Here also the flats, treeless or with occasional yellow or lodgepole pines, were common.

The morning of the 29th found us early in the saddle with thirty miles to go to the evening's camp. Our trail followed White River to its source. In places of precarious and even dangerous footing we found it safer to lead than to ride our horses. For many miles the trail led through a burned forest with its usual scene of devastation, but as we gained elevation we had an unobstructed view of the rugged landscape. On our right the land swept up in gradual ascent to the Continental Divide and to our left fell away to the bed of White River. For considerable distance it was a river in name only, disappearing completely under its gravels and reappearing suddenly in full view. Later our trail emerged on a flat area known as the "Meadows," where rather scant grasses and sedges were cut by dry watercourses fringed by low willows and dwarf birch (*Betula glandulosa*). The river had now dwindled to a mere brook.

So far our ascent had been easy and gradual, but suddenly the trail left the stream and led us eastward. By a series of "switchbacks" or zigzag turns we began to climb the divide and for an hour or more ascended steadily a rather stiff grade. The lodgepole disappeared and the whitebark pine became general in its orchard-like formation. Suddenly as we topped a spur we looked over into a grove of Lyall's larch and knew that we were not far from 8,000 feet. A few rods farther and we stood on the Continental Divide. The aneroid indicated 7,900 feet. We now dropped rapidly



WESTERN YELLOW PINE

A FAMILIAR STAND ON SOUTHERN SLOPES AND FOREST-PRAIRIE MARGINS IN THE REGION.

on to the Missouri drainage at the head of Moose Creek, a tributary of the Sun River.

Our view of the main range of the Rockies from the White River canyon had presented no features of special interest. Immediately, however, on gaining the crest a thrilling view was unfolded to our gaze. The eastern face of the divide dropped perpendicularly a thousand feet and reached away southward mile upon mile. These huge cliffs of limestone, known as the "Chinese Wall," are the edges of strata dipping to the valley of White River. They vary in alternate promontories and shallow bays, the former rising as peaks along the crest. It was a magnificent view which gained in impressiveness as we made our way around the end of the wall and down under its broadening shadow at the close of the day.

It was sundown at four o'clock, but the next morning the sun rose over the rim of the world at six and looked straight into the door of our tent, a unique experience in the mountains where camp is usually made in a hollow, where shadows lie late in the morning and come early in the evening. The day was spent here in working over the old collections and adding new. Our climb to the top of the divide at one of the lower gaps was rewarded by one of the finest views of the trip. Here at somewhat over 8,000 feet there spread out before us a wild expanse of canyons and peaks as far as the eye could reach.

A burned forest covers the western slope almost to the crest of the ridge. The wind-swept top of the divide bore only dwarf vegetation represented by draba (*Draba andina*) closely nestled among the loose stones and of much the same color. *Arctostaphylos alpina* spread in close mats over the rock. In the lee of the top, on the east side, golden buckwheat (*Eriogonum Piperi*) was in full bloom, also columbine (*Aquilegia flavescens*), cinquefoil (*Potentilla perdissecta*), *Senecio Purshianus* and *Festuca rubra.* On the lower ground the dominant almost sod-like association of bear grass prevailed. In wet places clumps of *Erigeron salsuginosus* and *Senecio triangularis* were frequent and one of the most abundant plants was the beautiful gentian (*Gentiana calycosa*), opening fully only in the bright sunlight. Engelmann spruce and sub-alpine fir were almost the only trees.

The next morning saw us again mounted. Our way now was not defined by trail but, guided by landmarks, we hoped to make our way to the west branch of the South Fork of Sun River. Keeping close under the wall between the forest and the cliff progress was made without much difficulty. But the country grew rougher as we advanced and became a succession of ridges and basins at the heads of various small streams.

Here one of the most interesting events of the trip transpired. We were now in the Sun River Game Reserve and were alert for a sight of the big game, signs of which had been visible for days past. Suddenly the packers signalled that elk were near. Stopping the pack train and dismounting we cautiously made a short detour to the left. We succeeded in getting within a stone's throw of some of the band before they took fright. Several of them stopped and gazed at us. The country having been burned over there was little obstruction to vision and we stood fascinated by the wild and beautiful scene before us. As the herd moved off across a wide canyon beyond we counted well up towards forty, and others that we could hear but not see left little doubt that there were fifty or more. The mating season was drawing on and the bulls were in full horn. Their calls rang bugle-like across the wide canyons. There are said to be about 4,000 elk in this reserve, and they

ACROSS THE VALLEY OF WHITE RIVER

LOOKING WEST FROM THE CONTINENTAL DIVIDE. PICTURE TAKEN FROM AN ALTITUDE OF 8,000 FEET.

are multiplying so rapidly as to be an encumbrance to the range. Consequently, the reserve was thrown open recently for a limited amount of hunting.

We made our way back to the horses in high spirits over this experience. But we were still further rewarded by the view of mountain goats along a ledge of the wall. They paralleled our course for some distance and then disappeared.

Finally we topped another high ridge and, turning our backs on the wall, descended one of the branches of Red Butte Creek, followed it to the forks and ascended the other branch toward a saddle which we had had in view for some time. Pulling up this about forty-five degree slope was the steepest ascent we experienced.

Dropping down on to Indian Creek along an old, abandoned trail, our way led through a burn of ten to fifteen years ago. The roots of the dead trees were rotting and thousands of trunks were thrown in all directions. We had literally to hew our way through and were hours making a few miles. A burn in this condition is always a dangerous place and that night in our safe camp on the West Fork a storm swept over and we were very thankful that we had got through. The vicissitudes of a steep and dangerous trail and the labor of threading through a maze of fallen timber left us no time here for collecting, so we decided to remain over a day and work the locality, which proved rather fertile.

The West Fork is more prolific in the operations of beavers than any other stream in the writer's experience. It is a shallow creek of twenty to forty feet in width, not too rapid and with low banks. Such conditions make building easy and a dam of four or five feet will sometimes impound water enough to cover several acres. Tall cottonwoods up to two feet in diameter are felled by these industrious rodents and various

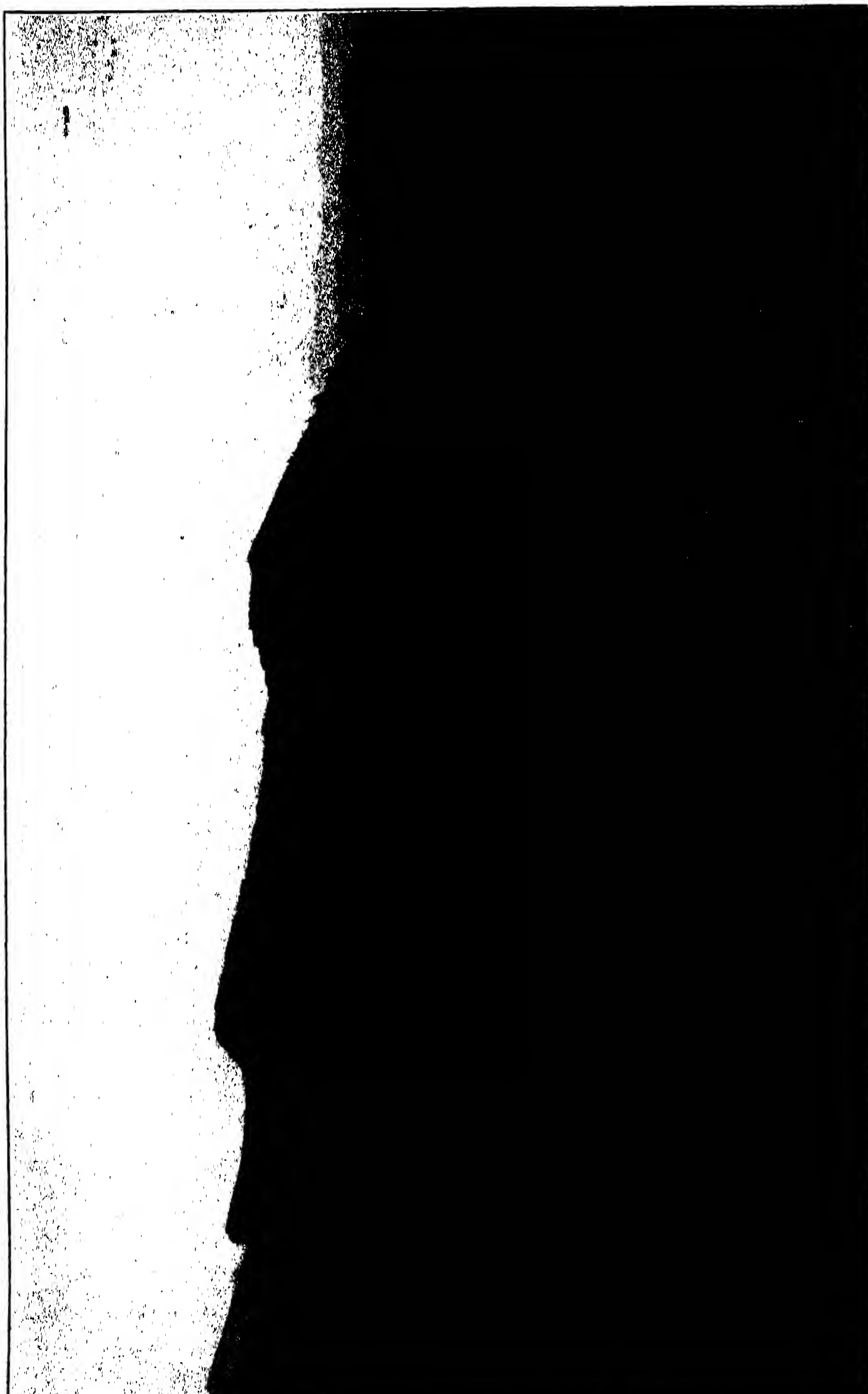
other woody growth along the banks is requisitioned and cut up for their purposes.

Such beaver ponds induce certain changes in the vegetation, first in a retrogressive, then in a progressive succession. The flooding of an area soon kills the trees and other vegetation upon it. Eventually these come down, floods and freshets sweep sand and silt into the pond, grasses and sedges spring up about its margins and after a varying lapse of years a meadow results. The meadow is not the final stage of the succession but the most obvious one. Willows, birch and cornel come in and spruce may follow as a climax. Or the silting process, if rapid, may so change the quality of the soil that drier conditions may intervene and change the character of the succession. Seldom if ever in this progress does peat moss appear. A sedge (*Carex rostrata*) is usually the dominant member in the early invasion of the ponds. In many places it is practically pure. Or grasses like *Alopecurus* and *Beckmannia* appear, and later, as the soil accumulates, *Panicularia elata*, *Juncus xiphoides*, *J. confusus*, or *Carex Mertensii* and other herbaceous plants varying with the location but not especially characteristic of the succession.

Another day brought us to Lakeside after a short ride of ten miles. An unoccupied cabin, a deserted camp and a corral in a grove of lodgepole pines at the border of a small prairie is all that is visible of Lakeside where the West Fork joins the South Fork. Our trail thither followed the stream at a little distance above it and along the foot of Prairie Reef a largely treeless elevation facing the south. The point of chief interest here was the aspen thickets scattered over the landscape. The trees were slender saplings twelve to fifteen feet in

ASPEN (*POPULUS TREMULOIDES*)

ON THE SUN RIVER GAME RESERVE. BRANCHES BROWSED TO UNIFORM HEIGHT OF 7 OR 8 FEET BY ELK IN WINTER.



THE "CHINESE WALL"

East face of Continental Divide. Top of the ridge about 8,000 feet. From the level of the forest to the top of the ridge is about 1,500 feet. Forest mainly sub-alpine fir.

height in island-like groves influenced in their occurrence by the presence of springs or seepage. They presented a very striking appearance as if pruned below to a uniform height of about seven or eight feet from the ground, due to the winter browsing of the elk. Everywhere within sight this feature presented itself with characteristic uniformity. Occasional patches of sage (*Artemisia tridentata*) appeared, indicative of the dry conditions, and along this trail we found the first specimens of the silver berry (*Elaeagnus argentea*). The coniferous growth in favorable spots consisted largely of lodgepole and some yellow pine, but on the bluffs above us appeared a scattering growth of limber pine (*P. flexilis*).

Turning sharply here we proceeded southward, ascending the South Fork of the North Fork of Sun River. This stream, somewhat greater in volume than the West Fork, runs almost parallel for much of its course with the Continental Divide and at a distance of two to four miles. Our altitude at Lakeside was about 5,000 feet, but gradually rose to near 5,800, where we camped at Wellman late in the afternoon, having traveled some fifteen miles. This trail passes alternately through areas of green and burned timber, lodgepole mainly in both cases. Here over considerable areas the mature lodgepole pine was associated with a dominant grass (*Calamagrostis scribneri*) as a ground cover. Along the streams cottonwood (*Populus angustifolia*) and willows (*Salix McCalliana*) (*S. discolor*) predominate. In its mature form this cottonwood very closely resembles the black cottonwood (*Populus trichocarpa*) of the Pacific slope, but the leaves are narrower.

After a night at Camp Wellman we continued for a mile or two along the stream and then swung to the right up one of the spurs toward the Divide. Just before reaching the summit and at an altitude of 7,500 feet or more we came upon the white Rhododendron (*Rhododendron albiflorum*). This was a decided extension of range for this shrub, as it had not hitherto been reported in Montana except from one station in the Mission Mountains (Mt. MacDonald), although previously found by the writer in various places in the Bitter Root Range.

The trail here follows the Continental Divide for some miles until it comes to the three-way ridge which separates the waters of Sun River on the east and those of the Blackfoot and Flathead on the west. Soon after reaching the top we came unexpectedly upon the party we had left at Big Prairie. We immediately joined forces and, making our way along the crest, crossed the summit of Benchmark Mountain at 8,522 feet, and descended on the Sun River side a few hundred feet to a grove of trees near a tiny stream, where we made camp. Above us towered the precipitous wall of the northwestern shoulder of Scapegoat Mountain.

Again we crossed the Divide and descended into the South Fork valley to Willow Creek. Most of the way led through green forests, mostly of lodgepole pine, until we emerged at the bottom upon an open grassy flat with some sage and shrubby cinquefoil and occasional groves of pine. Here we laid over a day, giving time for some observations and collections.

Small streams traverse this basin on the way to the South Fork some miles below. Here we have one of the most extensive areas affected by beaver workings. This may cover a total of a square mile or more in extent and exhibits early and late phases of the succession, standing water, the sedge phase, the willow and birch association, etc. Many acres are covered now with a uniform growth of willow, only two species observed (*Salix McCalliana, S. subcoerulea*) and

Birch (*B. glandulosa*) about five to six feet high. The animals are still industriously trying to reclaim their pond and are succeeding in throwing the water back again over much of the ground once lost to the vegetation. Where the ground is bare the coal-black soil of almost pure vegetable origin is exposed to view. Here again *Carex rostrata* is the dominant plant in the first invasion and covers a considerable area in a pure stand.

From here we turned again toward the Blackfoot Valley and took our way up Danaher Creek, keeping the bluffs on our left and the willow flats on the right. Danaher Mountain loomed before us, a rugged mass. We rose by insensible degrees, and reached the pass at the low elevation of 5,400 feet. So wide and flat is this remarkable pass that the first intimation that we had of having crossed the summit was in observing the reversed direction of the stream flow. Descending by stages as gradual as those by which we had ascended we came soon to the Dry Fork of the Blackfoot River. For miles the bed of this river is entirely dry, strewn with smooth stones and gravel, the stream flowing below the surface.

Camp was made on the North Fork of the Blackfoot a short distance below the falls. All day the sky had been dull and lowering and sprinkles of rain now fell at intervals. We had scarcely made camp safe for the night when it began to rain in earnest. It rained much during the night and at some place above us must have assumed the proportions of a cloudburst, for in the morning the stream, usually clear as crystal, now ran full, turbid and yellow. Here of course, on the last morning of the trip and under conditions least agreeable for such a circumstance, our usually well-behaved horses had taken the notion to strike out for parts unknown. The packers were early astir, but it was ten o'clock before the bunch were rounded up.

The trail from this point follows the river most of the way, although often forced up the mountain and around bluffs here and there with precarious footing in loose and sliding talus. Much of the way is through green forests that have escaped the ravages of fire. The big tamaracks and yellow pines again appear as on the Monture some distance to the west. Passing this belt we enter once more the agricultural country some seventeen miles from Ovando and our trip was virtually at an end.

We emerged abruptly upon the Kleinschmidt Flats. Winding in and out among the pines is an old wagon road. Autos were awaiting our arrival and as the need of the horses was now over, we transferred their loads to a truck and dismissed the packers. A hot supper and a night ride to Ovando closed the day. We had swung around a loop of nearly two hundred miles.

LAMARCK AND THE EVOLUTION THEORY

By Professor RALPH F. SHANER

UNIVERSITY OF ALBERTA

FEW of the recent articles on evolution mention any name older than Darwin. Perhaps this is well: we have enough to regret in the present controversy. The omission is evidence, just the same, of a general belief that the modern evolution theory began with Darwin, and that all earlier writers possess only historical interest.

There is indeed a sharp distinction between the modern theory and those proposed before it. The line should be drawn, however, not when the "Origin of Species" appeared, but just fifty years earlier, when Lamarck published his "Zoological Philosophy."

Lamarck approached the evolution question near the close of a singularly fruitful scientific career. Up to the age of fifty, he occupied himself exclusively with botany. Then, in 1793, the Museum of Natural History in Paris was reorganized. Lamarck was transferred to an utterly new field and appointed "professor of zoology, insects, worms and microscopic animals." At a time of life when most scientists are content to glean the stubble of more fruitful years, Lamarck began the study of the least known part of the animal world. He determined the position and affinities of thousands of forms, improved the existing classification of Linnaeus and Cuvier and laid the foundation for invertebrate paleontology.

With the growth of his knowledge of vegetable and animal life, Lamarck reached the point when he could no longer harmonize the facts with the prevailing doctrine of the fixity of species. In spite of opposition and ridicule, he became an evolutionist. His beliefs are set forth in several works, but perhaps most fully in his "Zoological Philosophy," published in 1809. In this work Lamarck attacks the problem that Darwin attempted to solve a half century later.

The "Zoological Philosophy" is generally considered a classic work. Like most classics it is seldom read. For this the modern student can plead some excuse. The book contains considerable superfluous matter — at least when judged by modern standards — so much so that the reading of it in the original French is an exhausting undertaking for the average doctor of philosophy. In addition Lamarck's style of presentation belongs to a past era in scientific literature. For those who wish to know more of the book than the stock quotations afford, the language obstacle has been cleared away by an excellent and very readable translation made by Hugh Elliott.[1] The following abstract of Lamarck's argument, given as far as possible in extracts from his work, but rearranged in a modern order, will show the nature of his theory of evolution and its place in scientific thought. Since Elliot's translation is more accessible than the original and his rendering of Lamarck's words better than any I can offer, I will quote from the translation.

To begin with, Lamarck had a clear conception of the uniformitarian principle. He believed, as we do to-day, that all events in past world history can

[1] "Zoological Philosophy," by J. B. Lamarck; translated, with an introduction, by Hugh Elliot, Macmillan and Co. 1914.

be explained best as the result of the operation of present-day forces of nature. The prevailing view in Lamarck's time was very different. The school of Werner, then at the height of its popularity, solved all geological puzzles by an appeal to floods that might have staggered the imagination of the writers of Genesis, and by calling in a chemistry as fantastic as medieval alchemy. Quite as popular were the Catastrophists, who laid the destruction of fossil forms to great disasters which at one time overwhelmed the world, utterly destroying every living thing. Lamarck, however, took his stand with Hutton and Demarest, and postulated the uniformitarian principle as the foundation for his evolution theory.

> Every qualified observer [Lamarck writes] knows that nothing on the surface of the earth remains permanently in the same state (p. 45).
>
> Naturalists who did not perceive the changes undergone by most animals in the course of time tried to explain the facts connected with fossils, as well as the commotions known to have occurred in different parts of the earth's surface, by the supposition of a universal catastrophe which took place on our globe. . . .
>
> But why are we to assume without proof a universal catastrophe, when the better known procedure of nature suffices to account for all the facts which we can observe?
>
> Consider on one hand that in all nature's works nothing is done abruptly, but that she acts everywhere slowly and by successive stages; and on the other hand that the special or local causes of disorders, commotions, displacements, etc., can account for everything that we observe on the surface of the earth, while still remaining subject to nature's laws and general procedure . . . (p. 46).

Darwin warmly acknowledged that it was Lyell who taught him to look for the cause of past changes among causes for change in the present, and thus started him on the road that led to evolution. Under far less favorable conditions Lamarck attained a thorough grasp of the same principle, without which no evolution theory is possible.

With Lamarck it is especially necessary to distinguish his evolution theory in the narrower sense; *i.e.*, his concept of the fact or law of evolution, from the causes or factors which he thought brought about the process of evolution. Lamarck does not separate the two very well, and subordinates the first to the second throughout his book.

Lamarck's conception of the law of evolution he gives in the following paragraphs:

> Nature has produced all the species of animals in succession, beginning with the most imperfect or simplest, and ending her work with the most perfect, so as to create a gradually increasing complexity in their organization: these animals have spread at large throughout all the habitable regions of the globe, and every species has derived from its environment the habits that we find in it and the structural modifications which observation shows us (p. 126).
>
> We must first recognize that the general series of animals arranged according to their natural affinities is a series of special groups which result from the different systems of organization employed by nature; and that these groups are themselves arranged according to the decreasing complexity of organization, so to form a real chain (p. 68).

The chain series concept was, of course, not new with Lamarck, but the following modification is:

> I do not mean that existing animals form a very simple series, regularly graded throughout; but I do mean that they form a branching series, irregularly graded and free from discontinuity, or at least once free from it. . . . It follows that the species terminating each branch of the general series are connected on one side at least with other neighboring species which merge into them (p. 37).

Lamarck thought of the animal kingdom as a great family-tree; indeed he illustrates his idea with a crude tree. Now it is precisely this concept of a branching series that distinguishes the modern theory of evolution from all that precede it. To Lamarck falls the honor of adding this essential feature.

The proofs for the law of evolution are usually assembled into three groups,

to form the arguments from comparative anatomy, from embryology and from paleontology, respectively — somewhat after the fashion of books on theism. Most of the evidence given by Lamarck falls into the first group.

The mutability of species suggested itself to Lamarck as an explanation for the difficulties he encountered in his systematic work. It should be noted that Lamarck, like Darwin, speaks of the evolution of species and genera. Modern writers seldom descend below the larger systematic groups in their discussion of the evolutionary process.

> The almost universally received belief [Lamarck writes] is that living bodies constitute species distinguished from one another by unchangeable characteristics, and that the existence of these species is as old as nature herself (p. 31).
>
> Meanwhile, the farther we advance in our knowledge of the various organized bodies . . . the greater becomes our difficulty in determining what should be regarded as a species, and still more in finding the boundaries and distinctions of genera.
>
> According as the productions of nature are collected and our museums grow richer, we see nearly all the gaps filled up and the lines of demarcation effaced (p. 37).
>
> How many genera there are, both among plants and animals among which the number of species referred to them is so great that the study and determination of these species are well nigh impracticable! The species of these genera, arranged in series according to their natural affinities, exhibit such slight differences from those next to them as to coalesce with them. These species merge more or less into one another . . . so that there is no means of stating the small differences that distinguish them (p. 37).

Darwin records a similar experience in the "Voyage of the Beagle." As he sailed southward along the South American coast he noted the gradual replacement of species by others closely allied to them. Later at the Galapagos Islands he was struck by the slight differences that separated the birds of the several islands from each other and from their relatives on the adjacent mainland. The likenesses and differences were those found in the individuals of a human family, which everyone attributes to descent from a common ancestor.

The other evidence given by Lamarck for the mutation of species is adaptation. Lamarck found that everywhere in nature animals seemed specially fitted to live where they were found. He could not help but think that species had suffered modification to fit them for their particular environment.

The evidence that Lamarck assembled to justify his belief in evolution would all be included to-day in the argument from comparative anatomy. He cites the foetal teeth found in some whales and interprets them in accordance with his theory, but otherwise embryological evidence is lacking, as one might expect from the state of that science before von Baer. Lamarck could lean even less than Darwin on the infant science of paleontology. He seems to have doubted that any species was really extinct, especially of higher vertebrates. The explanation for this may be that Lamarck was best acquainted with the then recent and sensational discoveries of Cuvier in the Paris basin. The rocks of this region are of comparatively recent date geologically, and afford fossil vertebrates closely allied to living forms.

The differences between fossil and living invertebrates, however, did not wholly escape him. He suggests as an explanation:

> May it not be possible on the other hand that the fossils in question belong to species still existing, but which have changed since that time, and become converted into similar species that we now actually find (p. 45).

So much for Lamarck's conception of the fact or law of evolution, and the evidence he brought forward for it. As has been said, he devoted but a small part of the discussion to this part of his

theory and was chiefly concerned to suggest and establish the causes or factors by the operation of which the evolutionary process was brought about. These causes or factors are Lamarck's best known contribution to the general evolution theory, and are linked with his name, as natural selection is with that of Darwin.

The primary factor Lamarck thought to be some unknown cause which impelled living matter to become more complex in structure and function. To this cause he refers only vaguely and indirectly. The clearest reference is in the following sentences:

> If the factor which is incessantly working towards complicating organization were the only one which had any influence on the shape and organs of animals, the growing complexity of organization would everywhere be regular. But it is not; nature is forced to submit her works to the influence of environment, and this environment everywhere produces variations in them (p. 69).

The paragraph just quoted is worth emphasis, for it has been overlooked by the majority of writers on Lamarck's theory. Exactly what Lamarck had in mind is hard to say. Osborn thinks that Lamarck did not contemplate a "perfecting tendency," and nothing elsewhere in the text suggests that he did. Perhaps Lamarck thought that the effect of environment would not be more than to produce lesser adaptations in preexisting forms, and that the production of radically different types, such as amphibia from fishes, would require a cause quite independent of environment.

A far more important cause of evolution, to Lamarck, was the interaction of the species and its environment. This factor he explains and illustrates in considerable detail, and formulates into his well-known laws. In the "Zoological Philosophy," these are two in number.

> First law. In every animal which has not passed the limit of its development, a more frequent and continuous use of any organ gradually strengthens, develops and enlarges that organ, and gives it a power proportional to the length of time it has been so used; while the permanent disuse of any organ imperceptibly weakens and deteriorates it, and progressively diminishes its functional capacity, until it finally disappears.
>
> Second law. All the acquisitions or losses wrought by nature on individuals through the influence of the environment in which their race has long been placed, and hence through the influence of the predominant use or permanent disuse of any organ: all these are preserved by reproduction to the new individuals which arise, provided that the acquired modifications are common to both sexes, or at least to the individuals which produce the young (p. 113).

The evidence, or lack of it, for these laws need not be discussed here. It should be noted that the laws as they read in the "Zoological Philosophy" make no provision for the origin of absolutely new organs. In a later work Lamarck expands his two laws into four, the second of which provides for this omission, and, as given by Osborn, reads:

> The production of a new organ or part results from a new need or want, which continues to be felt, and from the new movement which this need initiates and causes to continue.

One can not rise from the reading of the "Zoological Philosophy" without wondering why it failed to impress the generation to which it was addressed and has been imperfectly understood ever since.

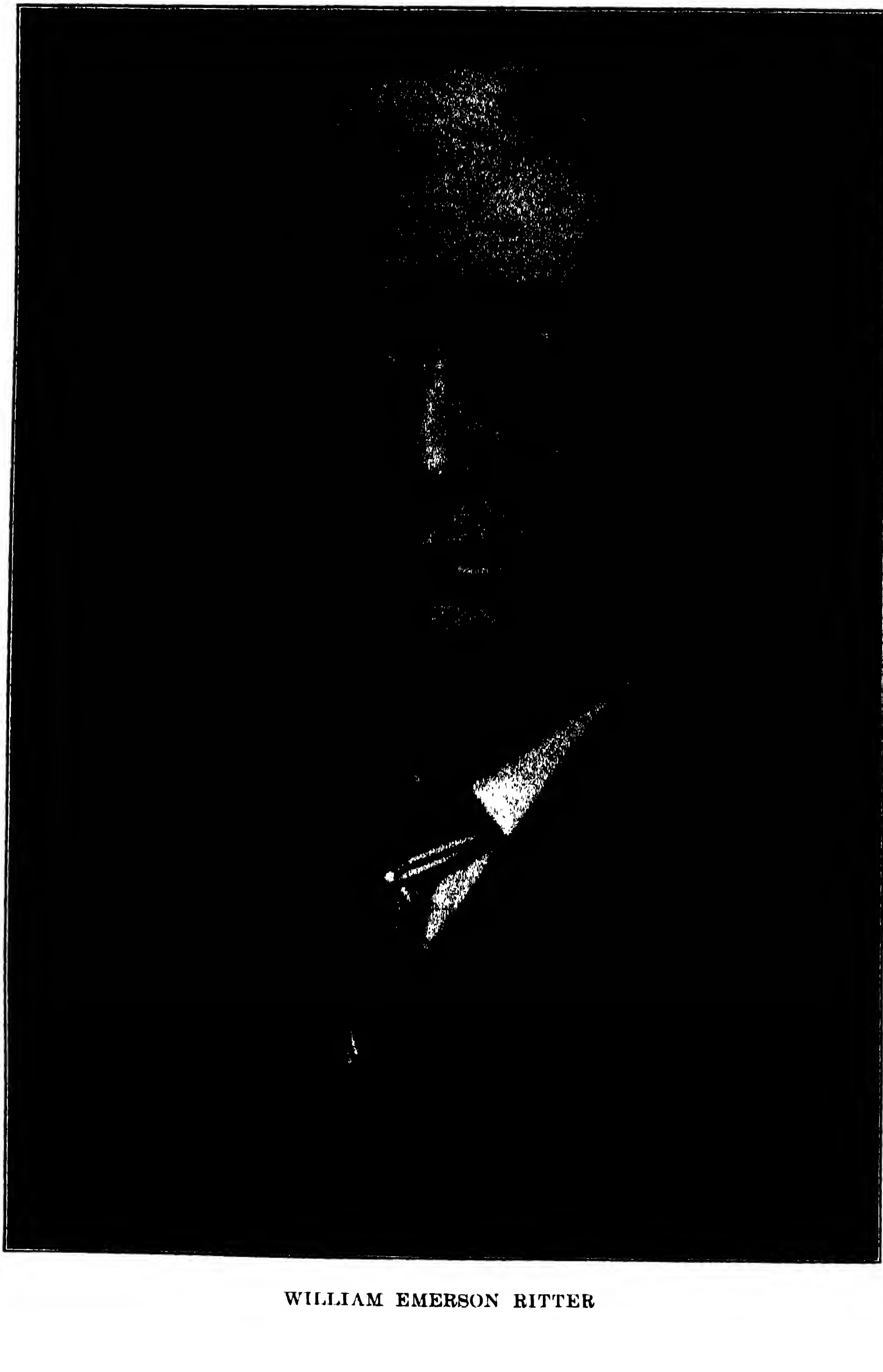
The contemporaries of Lamarck were dominated by catastrophic geology on one hand, and by the fag end of the Linnean era on the other. A modern evolution theory and eighteenth century geology are utterly incompatible. Neither would enthusiasts for classification welcome such slippery things as mutable species. Lamarck's first task should have been the methodical accumulation of evidence to prove that evolution really has taken place. Instead he did little more than summarize his personal im-

pressions. Then, taking the law of evolution for granted, he devoted his time to the discussion of the causes which might bring evolution about. His readers, decidedly not convinced of the reality of evolution, would not seriously entertain arguments for its causes. To make matters worse, most of the arguments that Lamarck advances for his causes of evolution are really illustrations and hence only concrete restatements of his thesis. A rigid proof of his laws transcended the knowledge of his day, as it still does ours.

To-day Lamarck is recognized as a scientific genius of the first order, the greatest figure between Aristotle and Darwin. Yet he is continually damned with faint praise. Eulogies are nearly always mixed with detractions. The credit for the uniformitarian concept has properly gone to Hutton and Lyell who gathered the evidence to prove it. For the same reason the glory for establishing the law of evolution has gone to the generation that followed Lamarck. Attempts have been made repeatedly to withhold credit from Lamarck for the laws or factors which are his chief contribution to biological thought. As is well known, Erasmus Darwin expressed substantially the same ideas a few years before Lamarck published. Darwin's statements are scattered here and there through the "Temple of Nature" and two other poems, and are vaguely sketched in a medical treatise entitled "Zoonomia." Despite any direct evidence, it has been insinuated more than once that Lamarck borrowed from Darwin without giving credit. Darwin's conception can be reconstructed only after a laborious plodding through a mass of doggerel, and by picking out a sentence here and there in the chapter on Generation in the "Zoonomia." After giving fullest credit to Erasmus Darwin's stimulating originality, surely some ought to be left for an independent thinker who worked out the same position and, in addition, formulated it in clear, definite and intelligible fashion.

No small part of the hostility to Lamarck among present-day scientists arises from *a priori* objections; different of course from those that closed minds to him a century and a quarter ago, but perhaps just as unreal. Evolution was to Lamarck, as it was to Charles Darwin and Huxley, not so much a progress upward as an adaptation to a changing environment. The three differed as to what part environment played, but all could agree that without a changing environment there would have been no evolution. Now present-day zoological thought is dominated by experimental physiology and genetics. The undoubted success of the experimental method in both fields has led many to prefer an evolution theory that will work *in vacuo*, or better *in vitro*, one that will operate without regard to environment. Accordingly the evidence for adaptation in nature is ignored or denied, and evolution theories that include adaptation as an essential part are opposed. Surely, the evidence of paleontology and of animal and plant distribution can not be ignored, even if it is not amenable to present-day experimental methods. When this is recognized a greater interest in Lamarck's theory can be expected.

The proof of Lamarck's factors, like the proof of other proposed causes for evolution, is likely to be a long and arduous affair. Those who believe that Weismann has disproved or that Guyer has proved the essential part of Lamarck's laws alike overlook the inherent difficulty of paralleling in a laboratory what is, by hypothesis, a secular process.



WILLIAM EMERSON RITTER

WILLIAM EMERSON RITTER: BUILDER

By Dr. FRANK E. A. THONE
SCIENCE SERVICE, WASHINGTON, D. C.

and Dr. EDNA WATSON BAILEY
UNIVERSITY OF CALIFORNIA

SEVENTY years is no longer regarded as the age of a man; we think now of a septuagenarian only as one who has begun his second maturity. Yet enough remains of the septuagesimal tradition that when a man reaches seventy we think it not inappropriate to pause and take stock of the things he has done to justify his length of days upon the earth. The recent anniversary of the birth of Dr. William Emerson Ritter called forth a group of communications from friends[1] who have worked with him at various stages in his scientific career, and these were of such character as to make it seem worth while to gather up their spirit and set it forth briefly in one place.

The stories of Dr. Ritter's coworkers begin with his coming to the University of California almost forty years ago, but the roots of his life as a scientist go much deeper than that. They apparently go back to the fundamental stuff of his mental makeup, and have been a part of him since he has had being at all; at any rate Dr. Ritter says that he can not remember a time when he was not interested in the things of natural history. As a boy on his father's pioneer farm in Wisconsin, he "could not step over a bone of a dead animal lying in the woods without stopping to examine it."

His first sally into the world of learning was made as a schoolmaster. The early days of the last quarter of the nineteenth century were exciting times for schoolmasters of a scientific turn, with the echoes of the first battle over evolution still sounding around the world, and the first giants of the modern dispensation of science in America striding among their startled brethren of the classics and the humanities on university campuses. Some of Joseph LeConte's writings fell into young Ritter's hands, and he went over the mountains forthwith, to search for this new kind of gold in California.

In those days all the natural history sciences at the University of California were lumped into one department and Joseph LeConte was their sole teacher. A few of the young men who came to him found they were more interested in living beings than in the story of the stones, and they began to collect and dissect and to roam the hills and beaches on their own account. The yield of these first efforts in practical natural history at the University of California was a rather remarkable group of naturalists; besides Ritter there were John C. Merriam, Theodore S. Palmer, W. L. Jepson and a bit later S. J. Holmes, Frank W. Bancroft and H. B. Torrey.

His first degree in science out of the way, Ritter did three very important things: took charge of the work in zo-

[1] Professors C. A. Kofoid and S. J. Holmes, of the University of California, Professor F. B. Sumner, of the Scripps Institute for Oceanography, Dr. J. McKeen Cattell, as chairman of the Executive Committee of Science Service, President R. M. Hughes, of Miami University, Dr. Edna Watson Bailey, of the University of California, and Mr. H. L. Smithton, friend and business associate of the late Mr. E. W. Scripps.

ology at the University of California, married Mary E. Bennett and went east to study more zoology at Harvard and incidentally to take his doctorate there, continuing afterward abroad, at Liverpool, Naples and Berlin. The first step cut out his first big task for him, that of organizing zoology at his alma mater; the second and third equipped him for this as well as for later tasks.

That he went to Harvard for his graduate work is significant for more than his formal training in zoology. His period there was during the heyday of the group of great Harvard philosophers. Having something of a constitutional weakness for the views of philosophy the exposure at this time and the later exposure to the same views through the Philosophical Union at the University of California brought on finally the disease of dissatisfaction in about equal degree with all varieties of subjectivistic metaphysics, on the one hand, and all varieties of materialistic metaphysics on the other.

Restoration to spiritual health came at last in the organismal conception of life combined with the natural history method of philosophizing. Some of the fruits of the intellectual clarification attained have been various books and journal articles, and various building operations, fashioned in accordance with the ideas elaborated in these writings.

Thus equipped and with such an outlook he found himself plunged into his work as the first teacher of laboratory zoology on the American Pacific coast. With all the rest he carried on a solid amount of research work, largely on ascidians and enteropneusts. He founded and edited the university series of publications in zoology, took a prominent part in reorganizing and revivifying the California Academy of Sciences, and shared in various scientific expeditions. It was a crowded dozen years.

The beginnings of one of the major enterprises of Dr. Ritter's whole lifework were taking form during this same congested period. They are best told by his colleague and friend of many years, Professor Charles A. Kofoid, of the department of zoology, University of California. In an unpublished article, prepared for this birthday celebration, Dr. Kofoid says, in part:

As early as 1900, Professor Ritter was casting about for ways and means for starting a marine station on the Pacific Coast which should serve the universities of the Pacific Coast as Naples had served those of Europe, or Woods Hole the colleges and universities of the East. In the summer of 1901 he gathered about him at San Pedro in an old bath-house transformed into a laboratory a group of his colleagues and students from Berkeley. The Oldroyds, the conchologists, came down from their truck farm, and teachers from the Normal School and high schools, the professor of anatomy from an osteopathic institution all joined with a will in a never-to-be-forgotten biological "baile" which lasted all summer. An improvised dredging outfit worked by hand and back was outfitted in the *Elsie*, a forty-foot gasoline launch, and with this and 200 fathoms of cable, a deep-sea thermometer, a plankton net, we attempted to explore the continental shelf from the Coronados to Catalina, with the aid of the osteopath's sturdy muscles.

The final result of this infant enterprise is to be seen in the Scripps Institution for Oceanography. The manner in which this was accomplished is one of the all-too-few romances of science. Unappalled by the inevitable deficits at the close of each season, Dr. Ritter never gave up for an instant his dreams that the way could be found to make the enterprise a permanent one. In the summer of 1903 the San Diego Chamber of Commerce at the instigation of Dr. Fred Baker, of Point Loma, undertook to finance by local subscription a summer's work of the University Marine Station. Two of the principal donors to the meager fund were Mr. E. W. Scripps, of Miramar, and his sister, Miss Ellen B. Scripps, of La Jolla.

These two donors had been long associated in newspaper and news-gathering enterprises, and their interest at first was only that of generous public-spirited supporters of a local enterprise. Out of this relation, however, there grew up from the very first a close and ever enlarging intellectual attachment and personal friendship between Dr. Ritter and these donors.

The attachment between the men rested upon a mutual understanding of certain rather deep-seated motives which guided these two men, who otherwise differed greatly in almost all particulars. The one was a masterful, dominating man of affairs, with a largely assumed indifference to culture and refinement, but withal with the keenest of intellectual grasp of the world's thought and life, and, under the mask of realism, a great idealist. The other came from the academic shades with the aspirations of the idealist and a program devoid of all immediate practical implications. The two had this in common, both were inquirers, both were earnestly seeking the truth, and both were believers that the truth, science, would set men free, if men could only come to know the truth.

The first Ritter-Scripps undertaking was the founding of what is now the Scripps Institution for Oceanography, at La Jolla, California. In this they had the active cooperation, as well as the very considerable material support, of Miss Ellen Browning Scripps. The "Scripps Institution for Biological Research of the University of California" resulted. It was designed as a year-round institution, with a permanent staff of full-time research workers.

Here was in germ an institution with a program of research on the life of the Pacific Ocean the carrying out of which would require a lot of team work. Fundamental investigations were the aim which no individual working alone could possibly compass. Hence the necessity for a salaried staff elected with reference to their special but correlated tastes, and trainings.

At the beginning, terrestrial as well as marine biology was contemplated in its program; but its location, if nothing else, inevitably caused the institution to look seaward ever more and more. For several years antedating his retirement as director, Professor Ritter considered such a modification of policy of the institution as would make it more strictly oceanographic, with a corresponding change of name.

His recommendation of such change was adopted by the regents of the university and a successor to the directorship sought in accordance therewith. After many months of search for the right man, the post was accepted by Dr. T. Wayland Vaughan. Shortly thereafter the name was changed to "The Scripps Institution of Oceanography," the understanding being that oceanography should be construed in the broadest sense. All aspects of the Pacific Ocean, both physical and biological, come at least nominally within the institution's research program. Thus, there now exists in vigorous infancy a full-rounded oceanographic foundation, the first in the Pacific area and in the Western hemisphere.

The characteristics of this institution which have given its activities unity and coherence during a life of many changes in name, place and now in leadership, are best summed up in Dr. Sumner's greetings from the Scripps Institution of Oceanography: "Despite the apparent unrelatedness and even incongruousness of the several branches of the institution's activities in past years, there have always been certain underlying ideas which brought them under a common viewpoint. For the Scripps Institution has had a creed, which its members have repeated with child-like faith, following the words of their father-confessor. One of the articles of this creed has been the importance of studying the relations between the organism and its environment. Another has been a recognition of the one-sidedness of either field or laboratory study, considered by itself, and the consequent need of combining the two for a proper understanding of vital phenomena. Still another has been the necessity of employing rigidly quantitative methods, so far as these may be applicable. Finally, the organism itself has been wholeheartedly recognized as

having a real existence, in its own right, and not merely allowed a provisional existence, pending its analysis into chemical, morphological or genetic elements.

"Now I think that most of us, at the institution, may fairly claim to have accepted the foregoing as working principles. That the Scripps Institution has no monopoly of this particular set of principles may be readily granted, but their explicit formulation for the practical guidance of a research establishment was certainly novel."

While Dr. Ritter was still director of the Scripps Institution, Mr. Scripps conceived the possibility of an institution for popular education in science through the daily press, in whose power he had great faith. Preliminary to a move in this direction, Dr. Ritter took a long swing around the circle of American universities, sounding out scientific opinion. Things looked propitious, and so Science Service was called into being. For the new organization a board of trustees was formed, representing the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, the newspaper profession and the E. W. Scripps estate; and Dr. Edwin E. Slosson was called from the editorship of the *Independent* to be its director. The results to date appear to give ample justification for Mr. Scripps' original idea, and the cooperation of the scientific world speaks well for its confidence in Professor Ritter and Dr. Slosson.

We have Professor Ritter's own word for it that the direction of his penetrating eye and still more penetrating reflection toward human conduct was due largely to the continual insistence of his friend E. W. Scripps. "This damned *human* animal—what is he?" To the bystander it seems likely that the fact that Mr. Scripps asked that question at all was due to his association with William E. Ritter. It is hardly the ordinary thing to find a business man, a humanist and a philosopher of sorts turning to a biologist for information as to the ways of men. Something in Mr. Scripps' knowledge of men—admittedly extraordinary—led him to feel that this particular biologist could interpret us to ourselves with sanity, science and common sense, could he but be badgered into the undertaking. Mr. Scripps' line of reasoning seems to have been: if scientific knowledge is useful and indeed indispensable to the most efficient making of glass and steel and houses and newspapers, it will in all probability be found to be equally useful and perhaps indispensable to the most effective conduct of all human affairs. In these he included, not just those humble affairs of getting food and clothing and curing ailments, but those high affairs of love of God and man, faith and hope and loyalty.

Like other thoughtful men of affairs, Mr. Scripps was haunted by the Malthusian specter. He realized that much of the accepted doctrine concerning the increase of population and its problems is based on erroneous or insufficient data. To assemble adequate and trustworthy information, on which to base decisions in the economic and social fields, the Scripps Foundation for Research on Population Problems was placed at Miami University, under the immediate direction of Professor Warren S. Thompson.

This mode of approach to the general enterprise of bringing science to bear on vital human concerns was, Professor Ritter insists, primarily Mr. Scripps' own venture. But neither he nor Mr. Scripps felt that study of human society alone could solve the knotty problem of what a single human being is, psychobiologically considered.

Faced with this task, Professor Ritter began to apply his naturalist's methods, as was his life-long custom. According to his own testimony, the naturalist's best motto is: "Neglect nothing." Applied to a creature of the complexity of an amoeba, this constitutes a sizable life-work. Applied to a human being, the task is staggering. It has called for delving with patience and precision into an enormous mass of material. Psychology, physiology, neurology, anthropology, sociology, with their many ramifications, have been explored and made to yield tribute. An onlooker at these tremendous labors is aware of a very good reason why biologists have not long since dealt thus with humans. The mass of facts and interpretations of facts to be synthesized is so great that we shall not often find a mentality able to cope with the task, or a temperament willing to tolerate its appalling exigencies. The mass of material demanding attention now is enormous compared to that available in Darwin's time. It is cause for genuine satisfaction that Professor Ritter has done certain fundamental thinking so thoroughly it need not be redone for some time. In the future, the humanist seeking sound scientific foundation for his concerns will find safe conduct through a great mass of irrelevant information and fruitless theorizing, because one man with human sympathy and superhuman patience has so faithfully "neglected nothing."

Another well-established procedure of the naturalist has entailed for Professor Ritter still further labors, and has yielded him even richer returns in the way of insight into humanity than that achieved by his comprehensive study of men alone. The methods of comparative anatomy and comparative embryology are familiar to all biologists for their fruitfulness. Men are to be understood as to conduct quite as they have long been understood anatomically. When we first made the acquaintance of the MSS of the "Natural History of Human Conduct" now in press, we read more or less patiently through long analyses of the behavior of ants, of woodpeckers, of beavers; of elk, and trout, and mayflies; but nothing at all as to the behavior of men, with whom the book was supposed to be specially concerned. It was a long while before we understood that when once we shall have achieved insight into the doings of woodpeckers and other folk, the key to the whole riddle will be in our hands. For a fuller explication of that riddle, we look to the next book, now approaching completion, "The Natural Philosophy of Human Conduct."

But significant information as to human animals comes not only from brute animals, but from the human animal himself while he is in the making. A new-born baby is anatomically pretty largely achieved; behavioristically, he has only entered the "gastrula stage" of his development. To study conduct in early childhood offers fascinating possibilities. The least exacting of environments, permitting the greatest freedom of behavior to children, is found in a modern nursery school. Professor Ritter's latest venture has been the establishment, in cooperation with another agency, of a Nursery School in Oakland, California. This institution is under the general direction of one of his former students, Edna W. Bailey. What glass-fronted aquarium tanks are to the observation of eels and starfish, nursery school play-spaces are to the study of the young human animal; with the added advantage of freedom and "every-day-ishness" quite impossible to the imprisoned sea creatures. There is no doubt that just this careful individual study through long stretches of growth will yield insight into adult conduct,

exactly as honest and painstaking analysis of animal activities gave the clue to their significance for human activities.

This latest phase of Professor Ritter's work is peculiar in that, while most of his life work has been directed toward pure science, this enterprise is concerned also with practical applications. Because of his insight into the nature of human capacity for regulating conduct with regard to organismal welfare, the results of these present observations are bound to be of arresting importance for education. Perhaps it is not at present justifiable to speak of education as an applied science; but if the trail which Professor Ritter is now blazing is carried through to its goal, there will be available psycho-biological knowledge adequate to the creation of such a science.

We are agreed without argument that "the race moves forward on the feet of little children"; we are willing to spend free-heartedly to smooth the road before these feet. To bring the great learning, the keen powers of observation, the sure logical mind, the fruit of a lifetime's ripened scholarship, into the service of children, not merely to smooth the old road, but to strike out a new and safer way to more abundant life—that seems a not unworthy climax to the life's work of a gentleman and a scholar who loves his fellowman. May his strength and his days be equal to the undertaking!

HOW FAST CAN MAN INCREASE?

By Professor EDWARD ALSWORTH ROSS
UNIVERSITY OF WISCONSIN

THE basis of our reproductive outfit comes, of course, from our prehuman ancestors. But the human period—at least half a million years if we may trust the prehistorians—affords an abundance of time for man's bodily evolution. In the course of this eon the human chin, the nose, the forehead, the big brain, the S-curved backbone, the straight thigh bone, the opposable thumb, the plantigrade foot and various minor bodily features marking off the human from the subhuman, are supposed to have reached their present stage. While the physique of man was thus evolving there *may have been* a development in the direction of greater prolificacy. This might be either by perfecting the generative apparatus or by sharpening the sex appetite.

SUPER-FECUNDITY AS A SURVIVAL ASSET

For this cause! Early man possessed in his brain an organ of use to him in living outside the natural dwelling-place of the prehumans; so he became the animal of least restricted habitat. But as man, overflowing his boundaries, met the trying conditions of life outside the warm forested region which was the home of his tree-dwelling, fruit-eating ancestors and had to cope with harsh climates or new enemies, and subsist upon strange food, his death-rate must have risen. Without weapons or defense, without remedy for injury or disease, dependent for food and shelter upon the chance offerings of nature, primitive men had nothing but their fertility with which to make good the destruction wrought upon them by the many hostile features of their environment. Often they must have had wit enough to avoid being promptly snuffed out, as is the animal clear out of its natural habitat, but not enough to make real headway against their foes. Many a human group, no doubt, wandered into a life so hard that as a rule more died than were born. Hence it disappeared. With a little more fertility it could have survived. Thus, as early men drifted into more and more risky areas, there was a premium put on prolificacy. The less fecund strains would be supplanted by the more fecund strains. In this way conditions may have favored the spread not only of the breed with the larger brain, the defter hand, the better-made foot, but also of the stock with the greater fruitfulness, say twelve births to a couple instead of ten.

If thus the human species continued to evolve in body and mind as it spread ever further from the original center of dispersion, there is no mystery in its having acquired what in our eyes appears as an *overload* of fecundity. What else *could* happen? For, in the long run and other things being equal, the fast breeders would outmultiply and replace the slow breeders. Still faster breeders would supplant *them*. Constitutional prolificacy *had* to increase until it came to be so taxing to its possessors that it was almost as great a handicap as an asset. At this point, of course, its development would cease.

LIFE-SAVING AGGRAVATES THE PROBLEM OF EXCESS FECUNDITY

There is another development which makes man's high prolificacy appear a nuisance. If Thomas R. Malthus (1767–

1834), the first thinker to establish that the happiness of peoples is threatened by the results of man's super-fecundity, had broached his ideas to the men of the Old Stone Age fifty thousand years ago, I fancy that they would promptly have rejected his contention that *always population tends to increase faster than the means of subsistence.* They would have pointed out that they met untimely death from disease, wild beasts or other men far oftener than from hunger. They would have said: "When times are bad our tribe dwindles, when times are good our tribe expands. But, on the whole, we have no more fecundity than we need in order to assure self-perpetuation."

Nor in the European Middle Ages, say the twelfth century, did the worries of life center about the question of victuals. In the words of the Dean of St. Paul's:

> The population question slumbered. The miserable chaos into which the old civilization sank after the barbarian invasions, the orgies of massacre and plunder, the almost total oblivion of medical science, and the pestiferous condition of the medieval walled town, which could be smelt miles away, averted any risk of overpopulation. Families were very large, but the majority of the children died. Millions were swept away by the Black Death; millions more by the Crusades. Such books as that of Luchaire, on France in the reign of Philip Augustus, bring vividly before us the horrible condition of society in feudal times, and explain amply the sparsity of the population.[1]

Again, right after the visitation of the Black Death in the fourteenth century would have been a poor time to warn against large families. Hecker[2] finds that:

> Cairo lost daily, when the plague was raging at its greatest violence, from 10 to 14,000; being as many as, in modern times, great plagues have carried off during their whole course. In China, more than thirteen millions are said to have died; and this is in correspondence with the certainly exaggerated accounts from the rest of Asia. India was depopulated. Tartary, the Tartar kingdom of Kaptschak, Mesopotamia, Syria, Armenia, were covered with dead bodies—the Kurds fled in vain to the mountains. In Caramania and Caesarea, none were left alive. On the roads,—in the camps—in the caravansaries,—unburied bodies alone were seen; and a few cities only remained, in an unaccountable manner, free. In Aleppo, 500 died daily; 22,000 people, and most of the animals were carried off in Gaza, within six weeks. Cyprus lost almost all its inhabitants; and ships without crew were often seen in the Mediterranean, as afterwards in the North Sea, driving about, and spreading the plague wherever they went on shore. It was reported to Pope Clement, at Avignon, that throughout the East, probably with the exception of China, 23,840,000 people had fallen victims to the plague. . . . In Padua, after the cessation of the plague, two-thirds of the inhabitants were wanting; and in Florence it was prohibited to publish the numbers of the dead, and to toll the bells at their funerals, in order that the living might not abandon themselves to despair.

The researches of Thorold Rogers show that in the England of five centuries ago food shortage was by no means the chief bar to population growth.

> The habits of the people were favorable to pestilence. Every writer during the fifteenth and sixteenth centuries who makes his comment on the customs and practices of English life, adverts to the profuseness of their diet and the extraordinary uncleanliness of their habits and persons. The floor of an ordinary Englishman's house, as Erasmus describes it, was inconceivably filthy, in London filthier than elsewhere, for centuries after these events. The streets and open ditches of the town were polluted and noisome beyond measure. The Englishman disdained all conditions of health.[3]

Very likely there have been many periods in which all man's fecundity was needed to insure the upkeep or replenishing of the population, and the difficulty of obtaining the means of subsis-

[1] W. R. Inge, "Outspoken Essays," 1919, p. 67.

[2] "Epidemics of the Middle Ages," 1844, pp. 23, 26.

[3] "Six Centuries of Work and Wages," 1884, p. 118.

tence was by no means the chief source of his troubles and anxieties.

The Debate over the Origin of Superfluous Fecundity

Malthus made his case against reckless propagation about the beginning of the last century when British statesmen were losing sleep wondering how the swelling population of the towns could be fed. In his time he had seen the birth-rate rise 6 per cent. and the death-rate fall 25 per cent. Since it is obvious that on an island not made of gutta percha this must reach a limit, he contended—reasonably enough, one would think—that unless births are fewer deaths will be increased in number by "checks" generated or aggravated by growing population pressure, *i.e., war, famine* and *disease,* until population ceases to grow. But in the third decade of the nineteenth century, thanks to industrialization and town crowding, the English death-rate rose and stayed up for sixty years. At the same time a colossal overseas movement of food made subsistence easier than ever to procure. So the impression grew up that the course of events had falsified Malthus's prophecies. Then, following upon the discovery of the real nature of infectious disease, came a great fall in the death-rate which has once more thrust the population question into the foreground.

In Malthus's time no one doubted that, some six thousand years ago, a benevolent God created man to be happy. As a clergyman Malthus was therefore hard put to it to account for our being created with a reproductive propensity quite in excess of current needs. Such a discrepancy seems to reflect upon the goodness or wisdom of God. Malthus could only argue weakly that man had been equipped with his imperious sex urge in order that by controlling it he might have opportunity to show character and prove himself a moral being.

Charles Darwin got his key to the development of species, the "principle of natural selection," from reading Malthus's "Essay on Population." As he read it dawned upon him that, if all species are as over-fecund as Malthus shows man to be, there will be a struggle for existence. Some individuals will go to the wall while others survive; and among the survivors will be those, otherwise fit, who happen to possess any advantageous variation in organ or trait. Thus is every species constantly molded into completer adaptation to the life conditions imposed by its environment.

It should be plain by now that our excess of fecundity is not a constant, but is relative and variable. It grows with progress in security, in peaceful association, in medicine, hygiene and sanitation. More individuals of each generation survive the perils of infancy; more reach adult life; more complete their reproductive period. So each generation has a bit more of excess fecundity to deal with. Writing to-day, when the infectious diseases are two thirds whipped and the mortality is but half of what he knew, Malthus could make a far stronger case than he was able to make in his time.

Of course, the foregoing is wasted on those who deny that man has evolved and insist that he was created just as he is. Since "God is good," it is impossible that our procreative propensity should ever prove a snare. Within the divinely ordained institution of marriage men and women may safely "follow nature." Hence, there is no "population question" save for peoples too lazy or wasteful or vicious or stupid to keep their food production ahead of the increase of mouths. Since no people is perfect, the orthodox are able to represent even the appalling poverty of the Chinese myriads as their own fault, as due to *under-production* rather than to

over-population. Thus all is shown to be for the best; we have but to go on and procreate as many children "as God sends."

Fecundity is not declining

We must reject the cheering argument of Herbert Spencer that civilization begets individuation and that, as individuation progresses, reproductive power declines. The fact is, the women of the most civilized peoples, if anything, are more fruitful than those of the less advanced. Theal found that 984 women of the Bantu blacks in South Africa had borne an average of 5.6 children. An investigator discovered that 160 Chinese wives, all over fifty years of age, had given birth on an average to 7.5 children. In Baroda, one of the native states of India, the average number of births for 28,011 completed families was 5¼. Four fifths of these women became wives at the age of thirteen or fourteen years. In the Punjab 34,561 unions of a duration of thirty years or more show 5.68 to a union. Ten thousand Bengal families in which the wife had been married at least thirty-three years yielded (including still-births) 6.34 progeny to a family. The genealogies of New England families show that in the first half of the eighteenth century the births per wife were 6.83. About 1912 an investigation of prolificacy in twenty-one rural counties of Minnesota showed that the wives born in Poland had produced on an average seven children in the course of fourteen and a half years of married life. When completed these families would certainly average ten or more children.

From the returns of the British 1911 census Stevenson calculated that the average number of children born to English couples married in the decade 1861–71 and surviving to 1911 was 6.79, while for couples married in the decade 1851–61 (when birth control was little known) the number was 7.28. While wives married twenty to twenty-four bore 5.83 children, those wedded fifteen to nineteen bore 7.41. Dunlop found that in Scotland women of the age group twenty to twenty-four who married 1861 to 1865 became the mothers of 7.8. In New South Wales the progeny of such unions was 8.32. The palm went to Scottish women married at the age of seventeen; their average was 9.02 children. The 1920 Census of Norway showed that for surviving couples who were married before 1888, the bride being but eighteen or nineteen years old, the type family was ten children. In Australia the births to wives married between fifteen and eighteen years of age and whose marriage had endured twenty-five to twenty-six years averaged 10.45. Doubtless similar figures would be found if such inquiries were prosecuted among the peoples of Central or Eastern Europe. It seems idle, then, to pretend that civilization solves the population problem by reducing the fruitfulness of women.

Maximum Rates of Human Increase

In a healthy population of normal makeup, in age and sex, whose fertility is checked by no other restriction than that of monogamous marriage, the birth-rate will range from fifty to sixty per thousand per annum. Birth-rates in the neighborhood of forty per thousand are not hard to find. This figure measures the fertility of Saxony thirty years ago, of Bosnia and Bulgaria just before the war, of Ceylon in 1917. In this class are Chile, the Central American republics and the West Indies. Birth-rates around forty-five we come upon in British Honduras in 1920 (45), Santo Domingo in 1910 (46.3), pre-war Roumania (43.1), pre-war Egypt (43.6), pre-war Russia (45.6), Serbia, 1886–1895 (43.4), Hungary, 1876–1885 (44.4), and Guatemala, 1876–1885

(45.2). A birth-rate of forty-nine was registered by Russia, 1886–1895, and in India at about the same time. It is so difficult to get a backward people to register all its births that many of these figures need to be revised upwards. Probably fertility comes nearest to natural fecundity in French Canada, where the devout *habitants* are forbidden by their priests to attempt any control over the size of their family. Quite often a priest, after returning for his parish a number of births which shows a rate of from fifty to fifty-five per thousand, adds the warning "many births are not reported." Certain parts of Quebec and certain regions in the Orient and Oceania appear to hold the world's record for prolificacy.

The advanced peoples have cut their death-rates per annum to sixteen, fourteen and even twelve per thousand; but such low figures are not for the quick-breeding peoples, which generally are rather ignorant, superstitious and fatalistic—poor soil for life-saving programs. Then, too, a prolific population will not only include a host of children—so frail and perishable—but frequent pregnancies and large families bring always in their train a high infant mortality. It seems safe to predict that even in this Golden Age of public hygiene no people with an annual birth-rate of fifty will have a death-rate below twenty—which gives an annual growth of 3 per cent. per annum. Such a population will double in about twenty-three years. In the last decade of the eighteenth century, when immigration was eligible, the increase of the American people averaged 30.5 per thousand a year, while in the first decade of the nineteenth century the rate was 31.5 a year. So far this performance holds the record.

We know of no contemporary population which actually attains this rate of natural increase. All the peoples bright enough to achieve a low death-rate are too wise to multiply in the blind way animals do. So many couples curtail family that by no means all the nation's fecundity is utilized. The highest annual rate of natural increase attained by any country throughout the entire period of authentic vital statistics was that of New Zealand, 26.6 per thousand for the decade 1876–1885. Only a country of recent settlement with a very small quota of old people could make such a showing. Quebec, Manitoba and Argentina report an excess of births above deaths of about twenty, which would double the population in thirty-five years. Just prior to the outbreak of the war, Roumania reported a natural increase of 18.4 and Bulgaria, 18.6. This is the maximum for Europe and would suffice to double the population in thirty-nine years. Russia had a margin of 17 in 1911; Holland follows with 16.3 in 1920—a gain not purchased by a very high birth-rate, but by combining a fairly high birth-rate with a very low death-rate.

Utilizing the life-saving means now available, a flourishing and enlightened modern population which welcomed large families might grow from its own loins at a rate which would double it in twenty-three years. To be sure, no people wise enough to keep its mortality low consents to breed in such reckless fashion; but we are told that it should do so if it is to avoid "sin."

THE BALTIC AMBER DEPOSITS

By Professor EDWARD W. BERRY
THE JOHNS HOPKINS UNIVERSITY

From the days of the Neanderthalers and Cro-Magnons, and possibly still earlier, man has been interested in the riddle of existence. Dim and feeble must have been the thoughts which the men of the Old Stone Age could spare from the pressing daily problems of food, shelter and life itself, for consideration of less mundane things, but that these had a considerable place in their thoughts is shown by the ceremonial burial of their dead and the ritualistic magic mirrored in cave art.

The accumulation of knowledge with the progress of the race has served to sharpen our interest in the meaning of it all, and although we are still ignorant of whence we came or whither we are bound, we do know that we are a part of a mighty current, eons old—a continuous garment of life with a warp of immutability and a constantly changing woof. We shall probably never be able to answer the Why? but we can discern rather clearly the main outlines of a history covering millions of years, and herein lies the great appeal of paleontology—the record of evolution, the chief handmaiden of historical geology and the principal scribe in the autobiography of the earth.

The votaries of the temple of science, while they may not bask in Roman luxury, will escape much of the pettiness of life and if they are really called to this high calling, will have more than their share of happiness. John Masefield in his introduction to a new edition of the "Travels of Marco Polo" says, "it is only the wonderful traveler who sees a wonder." Here is a moral for every one! The twentieth century mind is too cursed with pragmatism, the spirit that sees beauty in the world appears to be dwindling all too rapidly. A forest to many is merely so many potential board feet of timber; a crag, that might be the haunt of spirits, is merely a source for road metal or building stone. There is the best of precedent however for saying that "life is more than meat, and the body than raiment."[1] After all, as Rebecca R. Williams puts it, " 'Tis the set of the sail and not the gale that determines the way we go." Information must be changed to inspiration. We must feel sympathetic to Vergil's sonorous "Gods of the Rocks and Soil" as the thrilling first line of the epic of geology. Thus attuned we may learn much concerning the past.

If you mention the city of Danzig to a paleontologist, does he think at once of the lamentable failure of allied diplomacy in recent years? Not at all! He thinks, if he is the sort of a traveler that Masefield had in mind, of the brown coal deposits north of the town between Putzig and Rixhöft and the wonderful fossil plants that have been found in them. If you mention Königsberg eastward across the Bay of Danzig your paleontologist does not think of Hohenzollerns or other unpleasant things, he may not even know that it was the birthplace of Kant, but he will know of the marvellously preserved relics of the ancient world preserved in the Baltic amber, that has been washed up on the beaches of Samland, and collected by man during the last ten thousand years or more.

[1] Matthew 6:25.

Samland lies between the rivers Memel and Pregel—Königsberg is situated at the mouth of the latter. The peninsula proper projects at the eastern horn of the Bay of Danzig from between the Kurisches Haff and the Frisches Haff. The country is low and poor and comprises moors alternating with coniferous forests. The climate is cold and forbidding—quite different from what it was in the long ago. Contemplation of the present scene in Samland should not blunt one's mind to the wonder that can be extracted from this barren stretch of coast.

With our sails thus set to the breezes from the past let us see what sort of tale it has to unfold.

Even a non-smoker knows that the better pipes have amber mouth pieces and that amber beads are to be preferred to beads of glass or bakelite.

The use of amber in making articles for smokers is of course quite modern, since the habit was not introduced to the white race until after the discovery of America, tradition crediting its introduction into Europe to Sir Walter Raleigh.

The use of amber for ornaments, however, is older than human civilization. The men of the New Stone Age, or Neolithic as it is called, the time when polished flint weapons were in general use and the art of pottery making was first practiced, knew and valued amber. Amber beads have been found in burials of that early age estimated to be about twelve thousand years old. They are found in the relics of the Swiss Lake dwellers, who built their houses on piles over the water, practiced the first known primitive agriculture and lived nine or ten thousand years ago. They are found in the first known Mediterranean civilization (Minoian) that flourished on the island of Crete before the time of the Trojan wars, and in the tombs of the Etruscans who lived in Italy before the Romans, as well as in the earlier bronze age burials.

Various words in Hindu literature alluding to some mineral that attracted chaff when rubbed have been suspected to indicate amber, but this is very uncertain. Our word amber is said to come from the Arabic word "anbar," introduced into Spain by the Moors and derived by us from the Spanish. The early Greeks called it electrum, or that which attracts, because when rubbed it will attract bits of pith, dried grass and similar objects. It is interesting that this Greek word for amber is the origin of our word electricity which means so much more in these modern days than the mere property of attraction.

The Romans sometimes used the latinized form of the Greek word for amber, but more commonly, as by Pliny, for example, they called amber succinum from their word "succus," which means gum, showing that they understood the real nature of amber. This study of the origin of names and the names by which the same object is called in different languages is exceedingly interesting and often of great historical importance. For example, if we could be sure that the Sanscrit word grass jewel really meant amber we would know that this substance was well known in the most ancient Aryan civilization.

Amber is very inflammable and its germanic name alludes to this property, the German word Bernstein meaning combustible stone. In Finland and Esthonia amber is known as meri-kivi or merre-kivio, which means sea stone, and we would be at a loss to understand the significance of such a name did we not know that for ages the waters of the Baltic Sea have been washing out bits of amber from the sands and clays of its bottom and casting them ashore. Before the days when man was intelligent enough to search in the ground for amber in the same way as any other

mineral is now sought, the sole supply of amber was obtained by hunting along the coasts of the Baltic for it, exactly as we pick up dead shells along any sea beach.

Homer mentions amber several times in the Odyssey, especially as a Phoenician article of commerce. It is also mentioned in the Bible. Along with stone weapons of the chase amber was probably one of the earliest articles of European trade, Svensén, the Swedish archeologist, attributing the apparently prosperous Neolithic culture in southern Sweden to the trade in amber.

But we may know how amber looks and how it got its name and still be ignorant of its origin. If we were asked to decide whether it was animal, vegetable or mineral we should probably call it a mineral, which would not be far from the truth, although it is really of vegetable origin and is nothing but the fossilized gum or resin of plants that lived and died millions of years ago. In life it was almost identical with the drops of gum that you see on old cherry or peach trees, on balsam, spruce and pine, and on many other trees.

As thousands of different kinds of trees have lived and died and become extinct in the distant past of earth history, many different kinds of gum have been preserved in the ground, all of which, if it does not look different, is commonly spoken of as amber, although the earliest amber of commerce which came from the Baltic region of northern Europe has a certain definite chemical composition and is often called true amber. By chemical analysis we learn that the amber from which the beads were made that are found in Etruscan tombs in such quantities came from the Baltic, for the amber now found nearby in Sicily has a different chemical composition. Hence we assume that the amber deposits in Sicily were unknown to the ancients.

We now know amber of varying composition from a great many localities. Sometimes it has been given a special name, like cedarite from western Canada, or burmite for the Burma variety, or ambrite for the New Zealand variety, or roumanite for that which comes from Rumania. All of it looks much alike and has much the same physical properties, and usually can not be distinguished except by very careful chemical analysis.

It has been found at very many geological horizons in the rocks, from those of Cretaceous age, which are many millions of years old, down to the present. Almost always it is associated with beds of coal or in deposits that are highly carbonaceous and contain the debris of the trees which furnished the gum. Of the very many localities where amber has been discovered I know but three which are in the Equatorial Zone. These are Burma, in southeastern Asia, the island of Haiti, in our West Indies, and Colombia, in northern South America. This is interesting because there are a great many gum-bearing trees in the tropics, and we may expect to discover amber at many places in the equatorial zone when those regions have been more thoroughly explored.

If this were all the story of amber it would hardly be worth the telling, but it is only the beginning. In trying to picture the past life of our earth we depend almost entirely on what we call fossils, that is, on the traces of former life that are preserved in the rocks. Usually an organism has to have hard parts to stand much chance of remaining intact long enough to be buried by sediments and preserved for millions of years. Hence our fossils will be the bones of the higher animals, the shells of sea creatures and things of that sort, usually broken. Soft tissues always decay long before they can be sealed up in the rocks so that frequently animals that lived in the seas in swarms, like the

sharks, are known from their hard teeth alone, all the rest having been dissipated before burial.

Of the myriads of insects that have inhabited the world from the early days all that fell in the water were not snapped up by waiting fish, but many were buried, and we often dig their remains out of the shaly rocks. Occasionally these show the whole insect in a crushed carbonized mass. More often nothing but the wings are preserved, and although much information can be obtained from wings alone, they are nothing like as satisfactory as if we could have the whole insect for study.

Now amber contains fossils. Not all of it, to be sure, but where amber has been collected from a single region for thousands of years many specimens with fossils inside will have been encountered. Naturally the gum of a tree will not accumulate in quantities sufficient or rapidly enough to imprison anything large, but small objects will be caught in the sticky gum and covered by it, and these will be preserved in all the perfection of life; every lens of the insect eye, every hair on its legs or feelers, will be hermetically sealed and preserved for all time. It is as though nature were preserving these small forms of life for future students in the same way a scientist mounts objects for microscopic study in Canada balsam.

If you will notice the ants going and coming on a modern tree you will realize how easy it would be to entrap them if the tree exuded a gummy substance, or if you wish to try an experiment along this line tie a piece of sticky flypaper around a fruit tree in the garden with the sticky side out and after a few days examine it and see what a variety of things it will have caught. That this was similar to the way the fossils that we find in amber were caught millions of years ago we know because of the kinds of things which it contains. All are crawling or flying things or such as were light enough to be blown by the wind, such as small flowers, plant hairs, tiny shells and the like. Among crawling and flying things we would expect those that frequent trees to be the most common, and this we find to be true. Ants and spiders are exceedingly common in the amber, and among the ants the wingless workers are more common than the winged forms, for it is they that forage about over the vegetation. Just the opposite is true in certain insect beds laid down in water and covered with mud. In the latter we would expect the winged ants, flying about in swarms at mating time, to be drowned much more frequently than the wingless workers, and that is exactly what we do find in such water laid deposits.

One might expect that the chances of many different kinds of things being caught in such small amounts of gum to be exceedingly slender, and yet more than two thousand different kinds of insects, spiders and plants have been described from the Baltic amber alone. We have to remember that these amber trees made gum over many thousands of years and if the whole forest caught but one insect a day, in the course of ten thousand years that would mean three and one half million insects, and one has only to have a house painted during the summer to realize how numerous insects are in the world.

At any rate the amber trees that grew in northern Europe during a time that the geologists call early Tertiary caught many things in the gum or resin that exuded on wounded surfaces or dropped drop by drop to the ground. Many of these hardened pellets in all amber deposits are tear-shaped, just as they dropped from the trees, and this form of occurrence gave rise to one of the pretty legends of mythology, that of Phaëthon, and his sisters the daughters of the sun (Helios).

Phaëthon, because of the promise of the Sun his father, insisted that he be permitted for one day to drive the flaming chariot of the sun across the arch of the heavens. With the willfulness of youth he could not be persuaded of the skill necessary or the dangers to be encountered.

As the dawn opened the doors of the east and the stars and moon retired Phaëthon sprang into the chariot and delightedly grasped the reins. The impatient horses darted swiftly forward outrunning the morning breezes. Soon they realized that inexperienced hands held the reins, they rushed headlong, leaving the travelled path. Poor Phaëthon knew not how to guide them, even had he the strength. He forgets the names of the horses and knows not what to do. With terror he sees the monstrous forms scattered over the heavens—the scorpion, the crab, the serpent and the great bear. He drops the reins in his fright and the horses, entirely without restraint, rush hither and thither, now too near the earth and now far above it, the clouds begin to smoke, the mountain tops take fire, fields are parched, vegetation blazes, cities perish and the rivers dry up, even the sea shrank because of the awful heat. Earth screening her face with her hands huskily besought Jupiter for pity and relief.

Then Jupiter the omnipotent, calling to witness all the gods, including Phaëthon's father, mounted his tower and launched a lightning bolt against the foolish charioteer, who fell head-long and flaming into Eridanus, the great river. The Italian Naiads reared a tomb to his memory and his sisters, the Heliades, as they lamented his untimely end, were transformed into poplar trees on the banks of the river, and their tears, which continued to flow forever, became amber as they dropped into the stream. That is why in southern Europe these tear-shaped pellets of amber are often called the tears of Heliades (the sisters of Phaëthon).

We know more about the life and times of the Baltic amber than any other amber deposits because they are the chief source of commercial amber and have been worked for so many years. Since 1899 the deposits have been worked by the state and have produced between 150 and 250 tons of amber each year. The industry centers around the ancient city of Königsberg, where, as early as 1790, a scientific society was organized. This is known as the Physikalisch-Ökonomischen Gesellschaft, and it has been publishing memoirs (schriften) regularly since 1860. Much of our present knowledge of the amber fossils has been contributed to this series by a host of specialists, and it has been the natural repository of the results of the scientific activities of the region.

In the earlier amber days much of the present Baltic was a well-forested land surface with a genial climate. After some thousands of years during which the trees wept gum in small amounts and died and rotted away, leaving on the ground the gum they carried and which was gradually buried in the forest litter, the sea commenced very very slowly to encroach on this old land surface. As it gradually flooded the forest it worked over this forest litter, and that is why the surface of the pieces of amber are worn and rounded by wave action. Such of it as escaped destruction was finally buried in the muddy seabottom in what is now a bluish sandy clay.

This clay in which the amber is preserved was deposited at the beginning of a marine stage in this region known to the geologist as the Lattorfian or Sannoisian stage, and since the localities from which these terms were derived are classical it is of some interest to describe them briefly.

The Sannoisian was proposed by a French geologist (Munier-Chalmas)

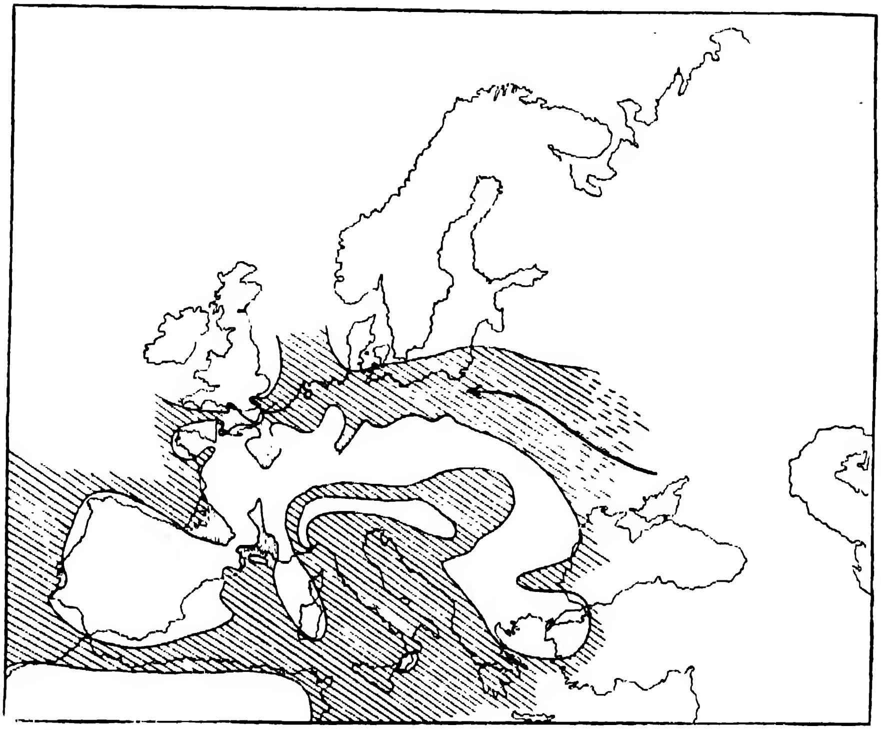


FIG. 1. MAP SHOWING APPROXIMATELY THE DISTRIBUTION OF LAND AND WATER IN EUROPE DURING THE LATTORFIAN STAGE OF THE LOWER OLIGOCENE. LINED AREAS ARE MARINE, DOTTED AREAS ARE ESTUARINE AND CONTINENTAL DEPOSITS. ARROW INDICATES DIRECTION OF INVASION OF NORTH GERMANY BY THE LATTORFIAN SEA AND FAUNA.

from the exposures at the village of Sannois near Paris. Here lying on top of the gypsum, which is now rather generally referred to the upper Eocene (Ludian stage) the following succession of beds is seen. At the base a dark, pyritiferous and gypsiferous clay with fossil fishes, turtles, a few crustaceae and molluscs, occasional mammal bones and leaves, reaches a thickness of about thirty feet and evidently represents sediments deposited in salt water of lagoons along the coast, but cut off from the sea. Overlying this dark clay are lenses of light calcareous clay varying in thickness up to forty feet and containing a few mammal bones, chara fruits and fresh water molluscs, evidently recording a freshening of the lagoon waters by the rejuvenation of the adjacent watershed. Above the light-colored fresh water clays is a thickness of from six to twenty feet of thin-bedded (laminated) clay with brackish water molluscs like Cyrena and Cerithium. This is the *marnes à cyrenes* of the French geologists, and shows a slackening of stream action and a renewed access of marine waters. Above the Cyrenia marls there is from twenty-five to forty-five feet of massively bedded, greenish, poorly fossiliferous clay of marine lagoons, and this is overlain by the Brie limestone, the last being the basal formation of the Oligocene, according to Stehlin, the vertebrate paleontologist.

Since this section at Sannois was deposited under somewhat abnormal conditions and therefore does not contain a typical marine fauna, most geologists

prefer to use the term Lattorfian, proposed by Mayer-Eymar and derived from the little village of Lattorf or Latdorf in Anhalt. Here, overlying about one hundred feet of clay and lignite, is found about thirteen feet of fine-grained, glauconitic and sparingly argillaceous marine sand in which are preserved vast numbers of molluscan shells. This is all that represents the Lattorfian stage at this locality, since the darker marine sands overlying the greensand contain a marine fauna which shows them to be of middle Oligocene age.

Lattorf is near Bernberg on the railroad between Berlin and Magdeburg, and near the latter is the village of Egeln, which is almost as famous as Lattorf for the lower Oligocene fossils which it has yielded, since it is principally from these two localities that von Koenen, the great German paleontologist, described over 750 different species of fossil invertebrates—mostly molluscs.

Students have been puzzled to account for the difference between this north German Lattorfian fauna and the antecedent Eocene faunas of western Europe, and have also assumed that it spread eastward across southern Russia into western Asia. Recent work in the last region by Lukovic, although not entirely conclusive, indicates that the south Russian and western Asiatic faunas are older than those of north Germany and that the Lattorfian sea as we find it in north Germany invaded that region from southern Russia and that the ancestors of this wonderful Lattorfian marine fauna dwelt in the Caspian and Aral regions.

The accompanying sketch map of Europe embodies this new conception of the extent of the flooding of that continent by the Lattorfian sea. (See Fig. 1.)

This sea gradually spread over a part of the old amber forests and buried them under a mantle of marine sands forty to fifty feet thick.

That the present Baltic covers part of the old amber forest we know because in the wash of currents and waves much amber is worked out of the submarine amber deposit and washed up on all the shores of the Baltic and even as far away as southeastern England, and it seems evident from this that the southern basin of the Baltic and perhaps a part of the North Sea was covered by similar forests during the emergent period that preceded this advance of marine waters over the old land; indeed, Tornquist, in his account of the geology of East Prussia (1910), concluded that the amber forests covered the whole Baltic basin as well as the Scandinavian peninsula, Finland and northern Russia, so that a part was submerged by the Lattorfian sea and much remained emergent along its whole northern shores.

An alternative view to the one here advanced was that of Heer (1860) who assumed that the Lattorfian sea and the amber forests were contemporaneous, the latter growing on the uplands that skirted the northern shore of this sea and that the amber was carried into the sea by streams. This is seemingly confirmed by Ulmer's studies (1912) of the caddis flies found in the amber of which the larvae of seventy-three species in thirty-five genera are considered to have lived in fresh water torrents. Such physiographic conditions would account for the numerous coniferous trees and for the northern elements in the apparent mixture of northern and southern forms in the amber flora and fauna.

It fails to account for the southern elements unless we assume that the upland was lofty enough to embrace several altitudinal zones. Apropos of this question Wheeler in his recent study of the "Ants of the Baltic Amber" (1914) notes for these insects an exactly similar situation as is shown by the plants, namely, that the northern types greatly outnumber the southern, as if the south-

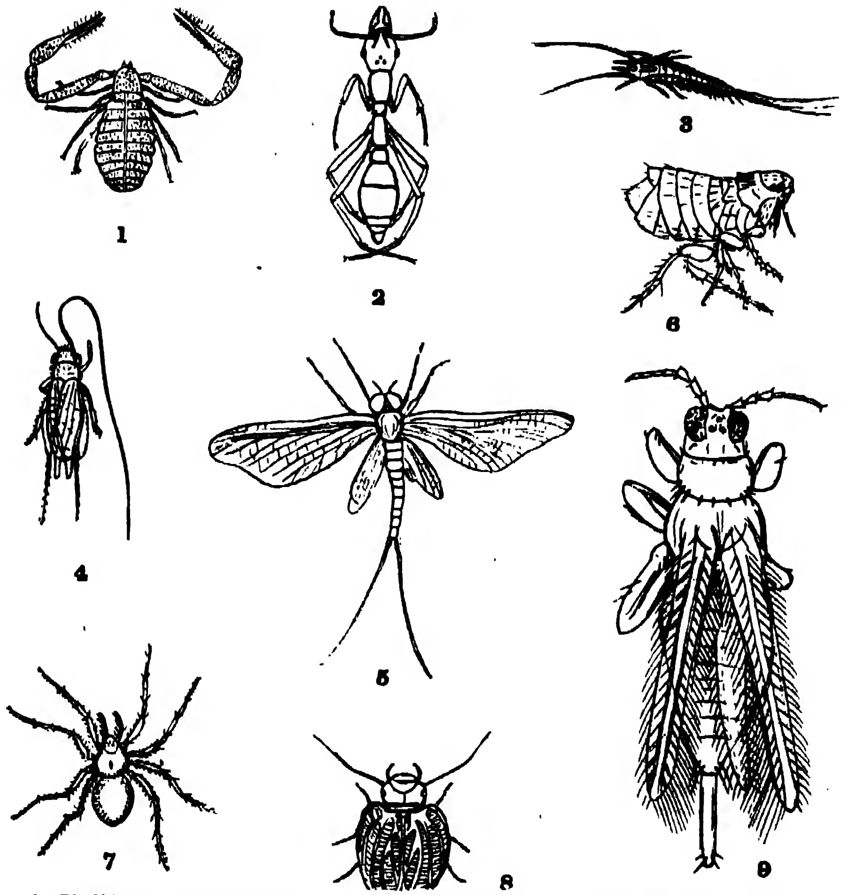
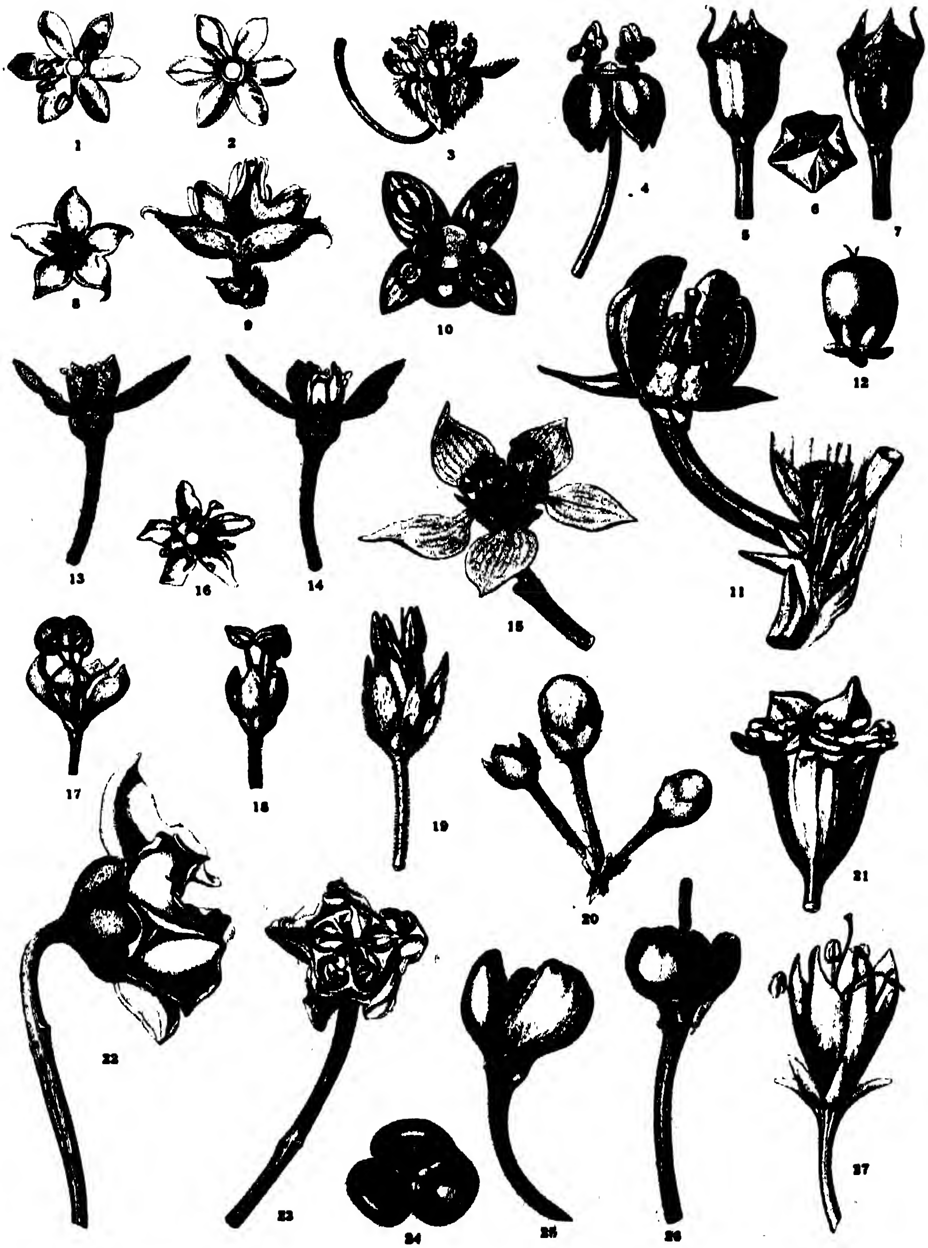


FIG. 2. 1. *Chelifer hemprichi* MENGE, ×9 (AFTER MENGE). 2. *Prionomyrmex longipes* MAYR, ×2 (AFTER MAYR). 3. *Machilus setiocornis* KOCH & BERENDT, ×2 (AFTER KOCH & BERENDT). 4. *Gryllus macrocercus* GERMAR, ×1½ (AFTER GERMAR). 5. *Cronicus anomalus* PICTET, ×3 (AFTER PICTET). 6. *Palaeopsylla klebsiana* DAMPF, ×12 (AFTER DAMPF). 7. *Misalia rostrata* KOCH & BERENDT, ×3 (AFTER KOCH & BERENDT). 8. *Sphaeropsocus kuenowii* HAGEN, ×15 (AFTER HAGEN). 9. *Stenurothrips succineus* BAGNALL, ×35 (AFTER BAGNALL).

ern were the survivors of the once dominant biota. If the region was one of warm lowlands and high uplands the plants and insects of the warm lowlands should outnumber the representation from the more distant highlands since the question of successful transportation would be a controlling factor, and this is not the case.

Eventually the Lattorfian sea receded and its marine sediments in the Samland region became a land surface which was soon covered with vegetation. During a long interval sands and clays, and especially swampy deposits, accumulated in the swampy depressions of this land, and the last was the source of the brown coal of the region. Many fossil plants are preserved in the brown coal series and although authorities are not entirely agreed as to the age of the series it is either later Oligocene or early Miocene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and constitutes the youngest formation in the region beneath the relatively modern Pleistocene cover.

The problem of the age of the amber is a difficult one and well illustrates the problems of paleontology. As I have already mentioned, the amber contains a great variety of the most beautiful fossils, and some of the insects, spiders and flowers found in the amber are shown in the accompanying illustrations. (See Figures 2 and 3.)

The very wealth and completeness of the material overwhelms us, for the geological timetable is built up by carefully establishing the succession of organisms in the rocks, and these organisms ordinarily are those most favorably situated for burial and most capable of withstanding the ravages of time, such as aquatic forms with hard parts, among which the mollusca may be considered as the dominating caste.

If plants are represented it is by wood or the more durable foliage, and not, as in this case, by flowers. Thus we have the problem of comparing flowers and insects with a time scale made from shells and leaves, and there is this additional perplexing factor. It is quite generally agreed that the sandy clay in which the amber is found is correctly assigned to the Lattorfian stage, but say the opposition: Although the clay is of Lattorfian age it is obvious that the trees which furnished the gum, along with the insects that foraged over them, and the plants whose flowers were entrapped, lived at an earlier time when the region was land and not sea, and you are confusing the time of their collective burial with the time that they lived, which is quite a different thing.

This is incontrovertible logic, but it is not so disconcerting as it seems, since the sea invaded but a fraction of the forested country and the amber forests continued to line its shores. This we know from the occasional amber plants that occur throughout the Lattorfian marine deposits. Furthermore, the seconds of the geological time clock are to be considered as of a thousand years' duration, and many generations of organisms can run their course in that time.

Indeed it is almost certain that the amber fauna and flora represent a mixed assemblage of preserved samples of the life of the times over a very considerable interval if measured in years, so that one can never be sure that the organisms in one piece were the exact contemporaries of those in another piece. When you find plant lice with their attendant worker ants in one inclusion there is no doubt of their contemporaneity, but we have very few records of this sort, since the custom in all large collections has been to cut the amber into small blocks which are then polished and mounted.

Here again it is not as confusing as it sounds, since all can be shown to belong to the same general stage of earth history, and it matters little whether we

FIG. 3. 1, 2. *Sambucus succinea* CONWENTZ, ×1½. 3. *Cinnamomum prototypum* CONWENTZ, ×4. 4. *Antidesma Maximowiczii* CONWENTZ, ×5. 5, 6, 7. *Thesianthemum inclusum* CONWENTZ, ×5. 8, 9. *Hamamelidanthium succineum* CONWENTZ, ×4. 10. *Myrsinopsis succinea* CONWENTZ, ×5. 11. *Andromeda Goepperti* CONWENTZ, ×5. 12. *Oxalidites averrhooides* CONWENTZ, ×3. 13, 14. *Cinnamomum Felixii* CONWENTZ, ×4. 15. *Connaracanthium roureoides* CONWENTZ, ×3. 16. *Pentaphylax Oliveri* CONWENTZ, ×1½. 17. *Ilex minuta* CONWENTZ, ×4. 18. *Ilex prussica* CONWENTZ, ×3. 19. *Adenanthemum iteoides* CONWENTZ, ×5. 20. *Celastrinanthium Hauchecornei* CONWENTZ, ×6. 21. *Stephanostemon Helmi* CONWENTZ, ×4. 22, 23. *Mengea palaeogena* CONWENTZ, ×5. 24, 25, 26. *Clethra Berendtii* CASPARY, ×6. 27. *Billardierites longistylus* CASPARY, ×3.

call them late Eocene or early Oligocene so long as we know exactly where they come in the paleontological procession, since it is particularly difficult all over the world to go out in the field and say that at any one point the Eocene ended and the Oligocene began. We are using human concepts of time units for that which was itself continuous.

I can see no conclusive reasons for following Conwentz, Jentzsch and others who regard the amber flora and fauna as Eocene; von Linstow (1922), for example, considers the latter to be as old as lower or middle Eocene, but both the flora and fauna are very different from any we know of that age. The southern element may represent the surviving part of the late Eocene biota at a time when the region was being overwhelmed by northern invaders; or the amber may record two more or less distinct facies—a southern and earlier, and a northern and later; or the northern may have come from the great north land as shown on the accompanying map, which would have had a somewhat more severe climate; and the southern may have represented the surviving warm fauna and flora of its southern coasts.

As I picture the amber forests from the evidence of the plants my picture agrees fairly well with that which modern authorities derive from a study of the insects, namely, that we have a mixture of forms whose existing relatives still live or could live at the same latitude with others whose relatives now live in warmer climes. Certainly, the climate was temperate and not in any sense tropical. This is clearly indicated by the abundance and variety of coniferous trees, as well as by the northern element in the insect faunas; but among them we find representatives of a number of warm-temperate types, and I think we are justified in concluding that the climate was much more genial, and the floras and faunas much more extensive and varied than is the case in Samland at the present time.

THE PROGRESS OF SCIENCE

EDITED BY EDWIN E. SLOSSON
Director of Science Service

SCIENTIFIC AMATEURS

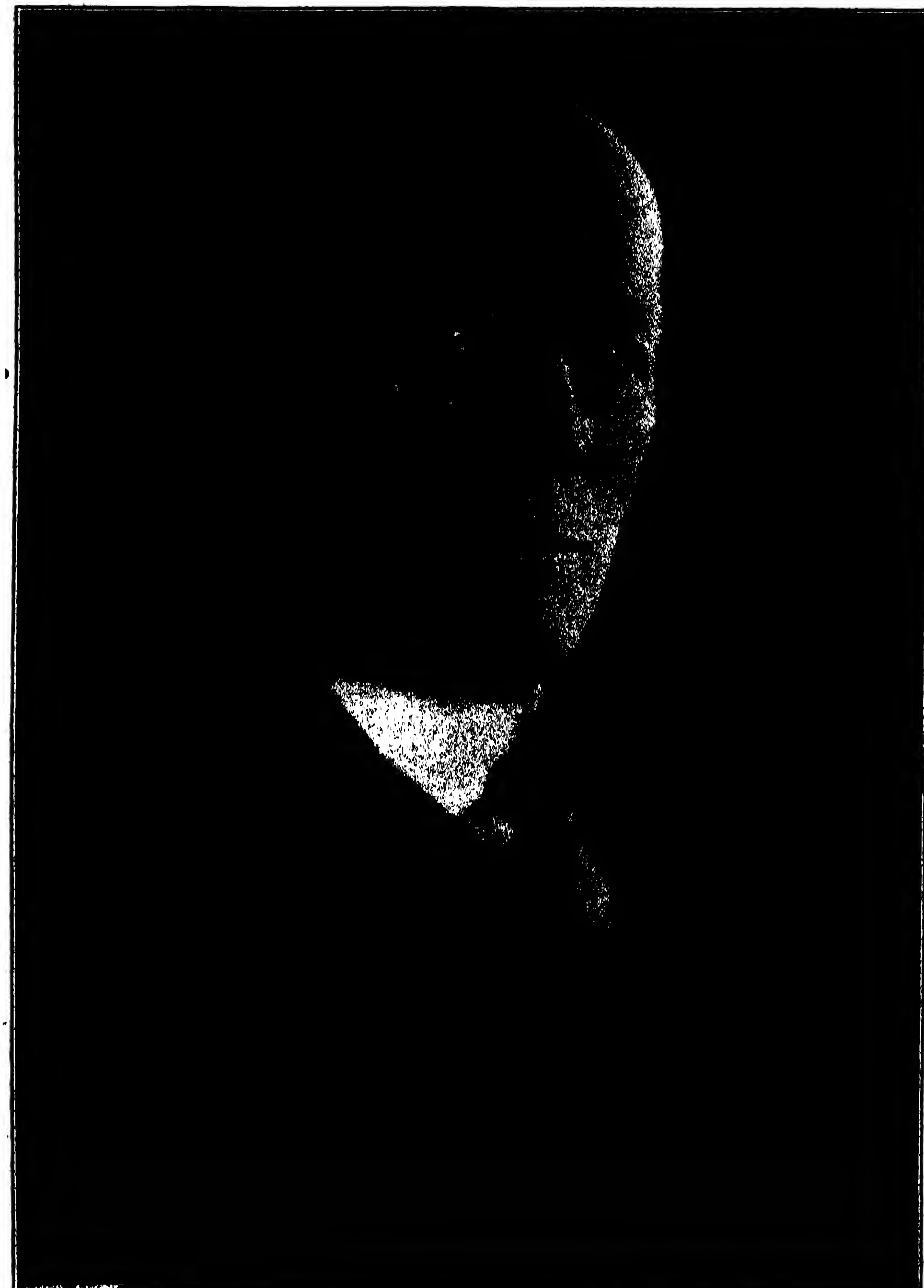
MANY workers in science now-a-days are business men, working in science as a hobby. Benjamin Franklin set the example for such scientific amateurs, for he was one of the first of them in America. A printer by trade, a diplomat by profession, Franklin was a scientist by avocation, and to read his autobiography, and to see some of his instruments which are still preserved in Philadelphia, one can hardly tell which side of his nature he was really most interested in. One has the suspicion, however, that he was chiefly interested in his science.

In England at the same time as Franklin there was another famous scientific amateur, using the word "amateur" in its best sense, a "lover" of science, not necessarily a novice. This was a clergyman, named Joseph Priestley, who made for himself a permanent place in the history of science by the discovery of oxygen. England has produced many scientific amateurs. Sir William Herschel, one of the greatest astronomers of all time, was originally a music teacher at Bath; and to-day, the secretary of the Royal Astronomical Society, and one of the leading astronomers of his country, is the Reverend T. E. R. Phillips, the active rector of a parish of the Church of England.

But the United States also has its scientific amateurs. Up in the hills of Vermont, in the town of Springfield, is a factory which makes machine tools. The president of the company gives the business his personal attention, and a few years ago was honored by his fellow citizens by being elected to serve a term as governor of his state. But James H. Hartness, for that is his name, has another side to his nature, like Benjamin Franklin. If you pay him a visit, he will probably show you around his works, and then take you to his home, on a hill above the town. At the back of his house there is a curious-looking structure, which at first glance bears some resemblance to a turret on a battleship, with a single gun sticking out from it. It is a turret, all right, but not a gun, for it is what Governor Hartness, who invented it, calls a "turret telescope."

With the usual form of telescope in an observatory dome, the inside of the building must be at the same temperature as the outside, otherwise the warm air from within will rise and go out through the slit in the dome towards which the telescope is pointed. This has the same effect as hot air rising from a stove and plays havoc with the distinctness of what the observer sees. But with the turret telescope, the instrument itself is mostly in the open air, outside the turret, and the image is brought inside by a reflecting prism. The inside of the turret may be kept as warm as desired as there is no opening for warm air to leave. To one who has gone through the rigors of a Vermont winter, this is a distinct advantage, and as a further convenience, Governor Hartness has an underground tunnel connecting the observatory with the cellar of his house.

There is a group of amateur astronomers, spread throughout the country, who perform scientific work of real value. This is the American Association of Variable Star Observers, which was



CHARLES DOOLITTLE WALCOTT

SECRETARY OF THE SMITHSONIAN INSTITUTION FOR TWENTY YEARS AND PREVIOUSLY DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY. DR. WALCOTT, WHO IS DISTINGUISHED FOR HIS CONTRIBUTIONS TO CAMBRIAN PALEONTOLOGY, HAS BEEN PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND OF THE NATIONAL ACADEMY OF SCIENCES. IN HIS DEATH, AT THE AGE OF SEVENTY-SEVEN YEARS, AMERICA LOSES ONE OF ITS MOST INFLUENTIAL SCIENTIFIC LEADERS.

established under the aegis of the Harvard College Observatory. With the building of the great telescopes in modern observatories, many people think that these instruments are essential to any observations of value. But while these telescopes have made possible the great advances in modern astronomy, there is still a large amount of work that can be done satisfactorily with smaller instruments. To use a great reflector for such a purpose would be about as sensible as to roll bread dough with a steam roller, for there is enough work to be done with the "Big Berthas" which only they can do, to keep them busy all the time.

A large class of stars are known as "variables." They change in brightness more or less periodically. Most of these are bright enough to be seen with a small telescope, but to check up on their variations a large number of observations, made fairly close together, are required. The American Association of Variable Star Observers, with its large number of small telescopes, watches these and its members report regularly to the Harvard Observatory. These amateur astronomers are drawn from all walks of life—one very active member, until his recent death, was a Pittsburgh locomotive engineer, who came in from his run about midnight, and then observed until daylight.

But astronomy is by no means the only science that has its amateur devotees. Take the instance of a prominent New York investment banker, who lives in one of the city's suburbs, Tuxedo Park. This man, Alfred L. Loomis, by name, has established at his home a private laboratory where he is experimenting himself, and aiding other scientists to experiment, on "long shots"—scientific problems that offer too little immediate return for the average university laboratory to investigate, but that may develop into something of importance.

Already, in cooperation with Professor Robert W. Wood, of the Johns Hopkins University, who is one of the world's leading experimental physicists, Mr. Loomis has investigated the super-sound waves that Professor Wood first observed during the war when he was working at the Toulon Arsenal in France. By passing a powerful oscillating electric current through a crystal of quartz, it is made to vibrate as fast as 200,000 times a second. The waves from this are similar to sound waves, except that they vibrate far too fast to be heard. The ear is not sensitive to vibrations faster than about 20,000 a second.

When the crystal is placed in the bottom of a vessel of oil, and its vibrations are passed upward into a glass of water, they produce strange effects. A fish placed in the water is killed almost instantly, microscopic plants are literally disintegrated, and when the curious investigator placed his finger in the water, a sharp pain, which extended to the very marrow of the bone, was experienced. Just what use this powerful new tool will be in science is still uncertain, for only the preliminary steps have been made in its investigation. It is where X-rays were a generation ago.

In an entirely different field of science, that of archeology, a hard-worked factory executive in Illinois has distinguished himself. George Langford, of Joliet, has taken up Indian mound excavating as many men take up golf. At that, he gets more exercise than most golfers, because what he has to do in his hobby is to work all day, when he has one to spare, with a pick and shovel like an ordinary laborer, with only one volunteer assistant to help him. But already his hobby has developed into a real pursuit of science, with important results, which has already won for him a place in the circles of his chosen science.

PRESIDENT COOLIDGE, MEMBERS, REGENTS AND ADVISERS OF THE SMITHSONIAN INSTITUTION

AT A MEETING IN WASHINGTON CALLED TO CONSIDER EXTENDING THE WORK OF THE INSTITUTION. THE MEETING HAD BEEN PLANNED BY DR. CHARLES D. WALCOTT, SECRETARY OF THE SMITHSONIAN INSTITUTION, WHO DIED THE DAY BEFORE THE SESSION STARTED, AND WHOSE LAST WISH WAS THAT THE MEETING BE NOT CURTAILED. LEFT TO RIGHT, FRONT ROW, SECRETARY OF THE TREASURY ANDREW W. MELLON; SECRETARY OF STATE FRANK KELLOGG; PRESIDENT COOLIDGE; CHIEF JUSTICE WILLIAM HOWARD TAFT, AND DR. C. G. ABBOT, ACTING SECRETARY OF THE SMITHSONIAN INSTITUTION. SECOND ROW, SENATOR JESSE H. METCALF, RHODE ISLAND; SECRETARY OF THE INTERIOR HUBERT WORK; SENATOR REED SMOOT, UTAH; SECRETARY OF AGRICULTURE WILLIAM M. JARDINE; SECRETARY OF COMMERCE HERBERT HOOVER, AND SECRETARY OF LABOR JAMES J. DAVIS.

His digging has been at the "Fisher mounds," near Joliet, and is important because he has unearthed three, and perhaps four, layers of remains of Indian civilizations that existed on the spot at various times in the past. In Old World archeology several layers of culture above each other are not unusual, but it is rare in America. Another important outcome of Mr. Langford's work is that for the first time a possible clue has been found to the earlier home of the Iroquoian Indian nation who played an important part in our colonial history. Previously, no remains of the Iroquois have been found west of Ohio, but in the second layer of the Fisher mounds pottery, ornaments and weapons suggestive of the workmanship of this race have come to light after remaining buried for many centuries. And under them are relics representing a still earlier group of Indians, about which little is yet known. Altogether, Mr. Langford has found hundreds of skeletons, as well as enormous quantities of the other relics.

STATIC AND THE WEATHER

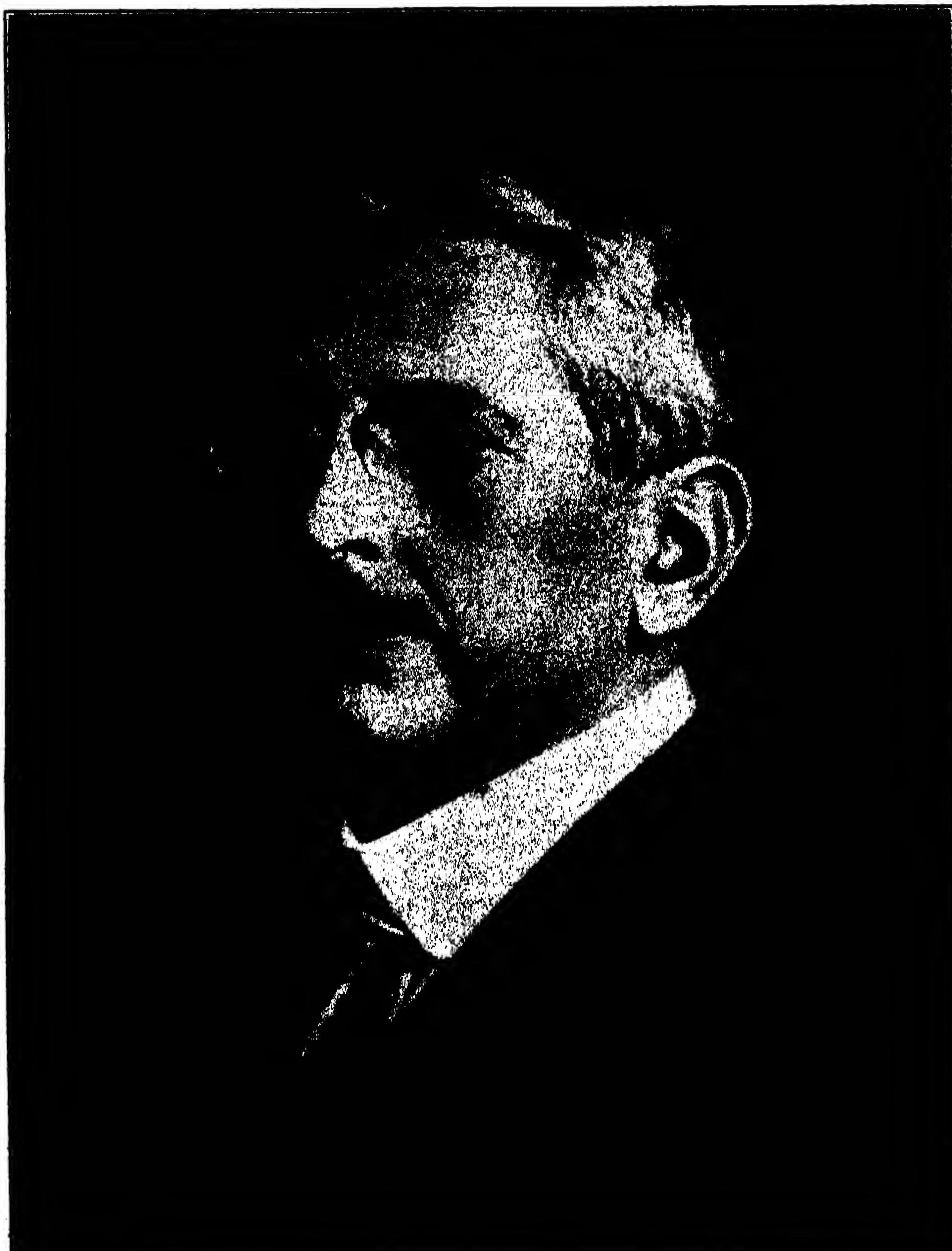
TURNING now to the work of the professional scientists, in this case the radio engineers with the U. S. Navy, some work has just been announced on the relation of static and the weather. These troublesome noises are the result of electricity in the atmosphere. But static may prove to be of some use after all, for the Navy Department has found that it may be used to warn of such storms as the hurricane that struck Florida last September.

Beginning in March, 1924, the *U. S. S. Kittery* was used in a study of the value of weather maps in navigation. Before the experiments had been under way very long, it was noticed that there was a very definite relation between the state of the atmosphere, as recorded in the data for weather maps broadcast from the naval radio station at Arlington, and the static. Later, when the weather maps were broadcast and received by means of the machine invented by C. Francis Jenkins, where a duplicate of the transmitted map is automatically drawn on the ship, it was found that the receiver could be used to record static.

The Jenkins machine is used in connection with a radio compass. The latter device is equipped with a loop antenna so that signals may be recorded from one definite direction. As the loop is rotated, and peals of static in any direction are detected by the receiver, corresponding ink lines are drawn on the paper-covered revolving drum of the Jenkins machine. In the time that it takes the recording pen to travel from one end of the drum to the other, the loop is turned through a complete circle, so that the paper gives a graphic picture of the static in any direction from the observer.

The *Kittery* was fortunate enough, from the scientific viewpoint, to meet the Miami hurricane several days before it struck Florida, when the static was terrific in all directions. But as the storm proceeded, the static came definitely from its direction. Finally, there came a day with no static whatever and fine weather, but then as a new disturbance began to develop, static was again recorded from its direction.

Such hurricanes begin in the doldrums of the Atlantic Ocean, off Cape Verde, the western tip of Africa, several weeks before they hit the United States. The Miami hurricane, for example, began about September 5, though it did not reach Florida until the 18th. It is suggested that a group of radio compass stations, perhaps at San Juan, P. R., a point in the Barbadoes, and Trinidad, would be able to detect these storms as they approach. With three stations, where the lines from each cross would be the center of the storm, so that its position could be accurately plotted and sufficient time for warnings and preparation could be allowed.



DR. GEORGE D. ROSENGARTEN

DISTINGUISHED PHARMACEUTICAL CHEMIST OF PHILADELPHIA, WHO HAS BEEN ELECTED PRESIDENT OF THE AMERICAN CHEMICAL SOCIETY BY A LETTER BALLOT OF THE 14,900 MEMBERS.

AMERICAN DIAMONDS

THOUGH little systematized search has been made, the complete total of diamonds found in widely scattered parts of the United States, if it could be checked up, would amaze the public that has long associated the queen of gems with the far places of the earth like Africa, Brazil and India. California, the Piedmont region of the Atlantic seaboard, and the region around the Great Lakes have all contributed some, but Arkansas is the only place in North America where diamonds are really mined.

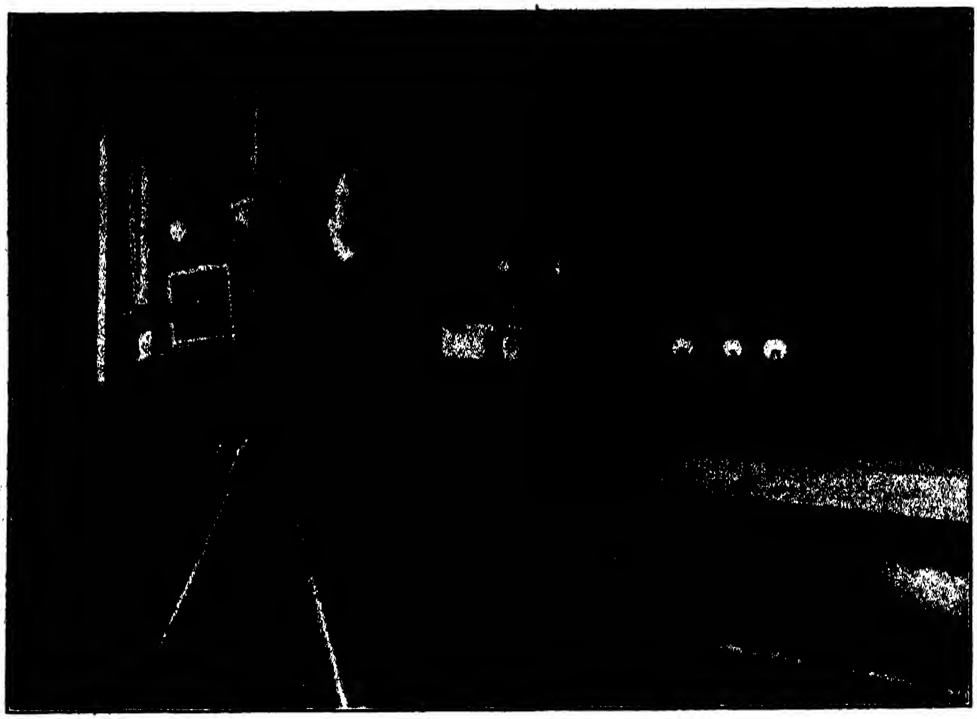
Experts put the total Arkansas output at over ten thousand stones since diamonds were first found in Murphreesboro, in Pike County, in 1906. Most of them are being held by mining companies, but a few have been sold and the best and most complete collection of them out of the hands of the mine owners is in the U. S. National Museum. The finest of this lot have just come to the Smithsonian Institution along with the quarts of quartz, pounds of topaz and ounces of opal, contained in the famous collection of precious stones of the late Colonel Washington A. Roebling. The largest native diamond in the museum, according to Dr. W. F. Foshag, who is working on the collection, weighs slightly under 18 carats and is one of the prize Arkansas specimens. The best of them all, however, came to light in 1924, tipping the jeweler's scales at 40.23 carats and is the largest diamond ever found on this continent.

The diamond deposits of the world are of two types. Those in Brazil, India and Australia, and some of those in Africa, are placers where the stones have been concentrated by wind and water. The occurrence of isolated diamonds in gold placers in this country is accounted for by the fact that the gold nuggets and diamond crystals are heavier than the other particles of sediment and gravel washed down from higher levels and are consequently fairly commonly deposited in the same locality. The second type of diamond deposit is in solid rock of volcanic origin or in the soft earth or clay overlying it. Like this is the Arkansas diamond region, as well as the world-famous mines of South Africa.

Several diamonds have been found and equally many have undoubtedly been lost in gold placers in California. They are thought to be originally derived from the same type of diamond-bearing rock that has been washed down in broken bits in streams from the mountains of volcanic origin. Most of them are small and there is no telling how many more of the white glassy crystals have been thrown out of the rockers and washing pans of miners interested only in the gleam of yellow dirt.

In the Piedmont region of the Atlantic coast there have been a few found. Virginia claims a single isolated diamond, a big one around 23 carats having been dug up by a laborer working on a street excavation in Manchester as long ago as 1855. In Dysartville, N. C., a shiny pebble later found to weigh four and two thirds carats attracted the attention of a little boy sent to a spring for water. He fished it out and carried it home where it excited sufficient interest on the part of the grown-ups to send it to New York for examination. It proved to be the real stuff and a model of it was displayed in the Paris Exposition of 1889. It is now in the Tiffany Morgan Collection in the American Museum of Natural History. Several others have been found in the mountainous parts of the state mostly associated with gold placers.

Several stones of considerable size have been found in the Great Lakes section. One weighing 15 carats was turned up in Wisconsin while a well was being dug. It was given to a woman who was a tenant on the property who sold it for a dollar, but litigation ensued when the real value of the stone came out.



THE TWO RECORDING INSTRUMENTS
ON THE LEFT, THE STANDARD MOTION PICTURE CAMERA WITH SYNCHRONOUS MOTOR DRIVE; ON THE RIGHT, THE SOUND RECORDER.

A SECTION OF THE COMBINATION SOUND AND PICTURE FILM
THE MULTITUDE OF HORIZONTAL LINES ON THE LEFT MARGIN CONTROL THE SOUND REPRODUCER.

TALKING MOTION PICTURES

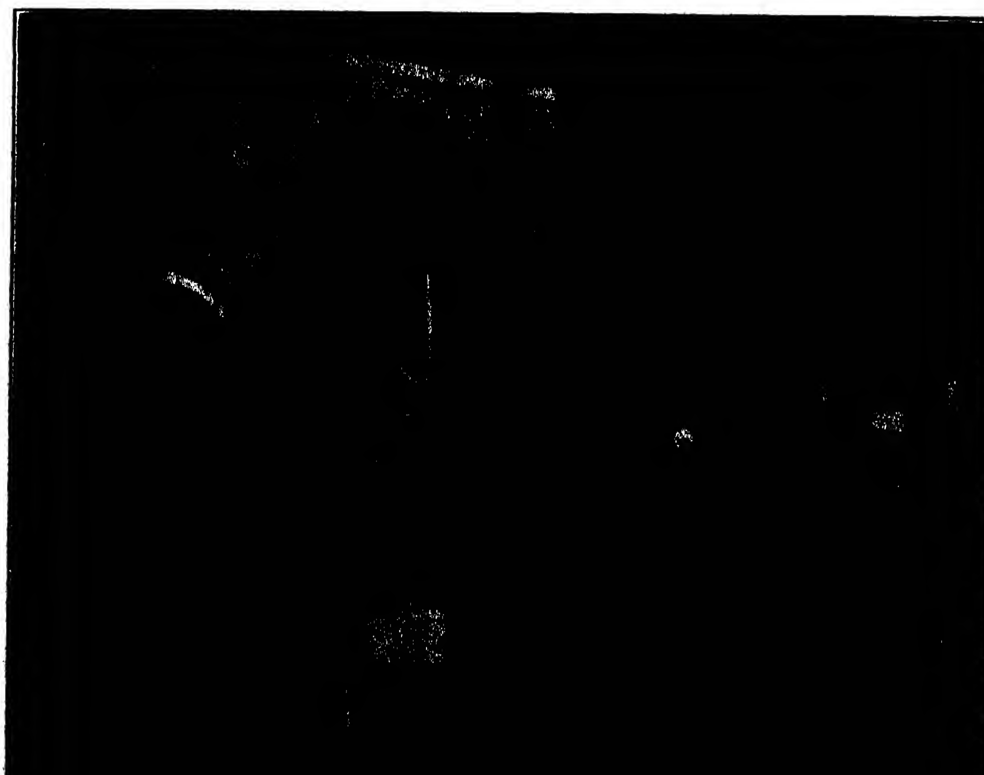
TALKING motion pictures in which the simultaneous timing of action and sound is assured have been announced and demonstrated by the Research Laboratories of the General Electric Company. The process means but slight change in standard motion picture projectors, since it involves only the addition of a sound-reproducing attachment and a loud speaker suitable for auditorium use. Both the picture and the sound are recorded on the same film.

One of the demonstrations has been with music to accompany feature films, the music being by a full concert orchestra. Development of this field requires no change in the technique of making the original film. After the original picture film has been made and titled, the accompanying music is played by a concert orchestra and is recorded on a film. The picture and sound records are then

printed on one film in the proper time relation.

To the casual observer the talking film does not differ from the usual motion picture positive. It is of standard width, but along the left margin there is a strip a small fraction of an inch wide on which is a series of horizontal light and dark bands and lines, of varying widths and intensities. It is this series of bands and lines which produces the sound. The film is passed through the reproducer at constant speed, and, as these light and dark bands pass rapidly before a tiny slit in an optical system, the amount of light is varied. The ever-changing amount of light is received by a photo-electric cell—the electric eye—which is extremely sensitive to any change in the amount of light striking it. The more light received, the more current it will permit to pass through its circuit. This current is amplified and changed from electrical to audible energy by an amplifier and speaker.

At this early date it is not possible to define the fields in which this new type of talking motion pictures will be of use. One of the first, however, will be in supplying a full orchestral accompaniment for pictures. The community picture house, accustomed to having a piano, or piano and violin, will be able to have the same music as the metropolitan theater.



COMBINATION SOUND AND PICTURE PROJECTOR

A STANDARD PROJECTOR IS USED, THE SOUND-REPRODUCING ELEMENT BEING MOUNTED DIRECTLY BELOW THE UPPER DRUM WHICH HOLDS THE FILM.

Another field is offered by the news reels. Not only will it be possible to show important persons, but they can talk to the audience, and visiting notables can extend their greetings.

Educationally, there are also many ways in which the new apparatus will be of service. Many schools and colleges are already equipped with motion picture projectors as an aid in class-room work, and the new film will be found of even more assistance. In the case of professors from abroad, it will be possible to record their lectures and demonstrations simultaneously, and to give their lectures the widest possible use by circulation of the film to colleges and universities throughout the country. Similarly, it will be possible to have an authority on the subject give a description to accompany any educational film for use in schools, the speech pointing out the important features of the picture simultaneously with their appearance on the screen.

Outstanding among the features of the new apparatus are that both the picture and sound records are on the same standard motion picture film, and that a standard motion picture projector, with an attachment for the sound reproducer, is used. Since the picture and sound records are printed side by side on the film, it necessarily follows that the two must be properly timed or synchronized at all times—it is not possible for the picture to break and the sound to continue, or for the sound to stop and the picture to continue.

There are three principal elements in the apparatus, including a standard motion picture camera, a sound recorder and a standard motion picture projector with a sound-reproducing attachment, all driven by synchronous motors. The pictures themselves are made in the usual way on standard film.

In recording the sounds, a microphone or sound collector of any desired type is employed, together with amplifiers. The microphonic system actuates a tiny vibrating mirror which records the sound on the film as light and dark bands, the light from a small incandescent lamp being reflected by the mirror through a tiny slit in the optical system in front of the film. The higher the pitch of note, the higher its frequency—and the greater the frequency of vibrations of the mirror which faithfully reproduces each sound vibration as a mark on the film.

The sound-reproducing attachment which is connected to the standard motion picture projector consists of a photoelectric cell behind the film and a small electric lamp with suitable optical arrangement in front of the film. As the film passes a small slit, similar to the one used in making the sound record, a varying amount of light is admitted to the photoelectric cell, the amount of light depending on the photographic density on the sound track. The result is that a very minute and varying current, an exact replica of the sound wave, is produced. This tiny current is amplified and led to a loud speaker which reproduces the sound in sufficient volume to fill the auditorium.

THE SCIENTIFIC MONTHLY

APRIL, 1927

CONTRIBUTIONS THAT HAVE BEEN MADE BY PURE SCIENCE TO THE ADVANCEMENT OF ENGINEERING AND INDUSTRY[1]

By Dr. C. R. RICHARDS

LEHIGH UNIVERSITY

It is, I think, safe to assert that those machines and processes which have revolutionized industry and the practice of engineering were originally evolved through accidental discoveries or pure invention; and that their later development has generally been based upon empirical knowledge. For a time empirical methods may be sufficient, but, sooner or later, every industry feels the need of precise knowledge of its processes or of its materials that can only be supplied through the aid of the fundamental sciences. No industry can feel secure until it is fully cognizant of the scientific basis upon which its activities depend, and that, through research in the fundamental as well as in the applied sciences, seeks to advance further its knowledge and improve its product.

The practice of engineering has been profoundly affected by the fundamental sciences, each of which in some manner has influenced the work of the engineer. In the practice of engineering it is no longer sufficient to work with rule-of-thumb methods; the engineer must be prepared to apply the accumulation of scientific knowledge to the more accurate solution of the problems with which he has to deal.

Believing that engineers and industrial leaders do not always recognize sufficiently the fundamental scientific principles involved in their work, it seemed advisable, in arranging the program for the Philadelphia meeting of Section M of the American Association for the Advancement of Science, that an effort be made to present the contributions that have been made by the fundamental sciences to the advancement of engineering and of industry; and, at the same time, to demonstrate that frequently the needs of engineers and of the industries have stimulated research in the fundamental sciences that affect them. The major portion of the program of the section was, therefore, in the form of a symposium at which each member of a group of distinguished scientists discussed the manner in which his particular science had influenced the work of the engineer and the development of industry. The importance of these discussions justifies their publication here, in the expectation that they will have a material influence in creating a better appreciation of the importance of scientific research.

[1] Papers presented in a symposium before Section M—Engineering—of the American Association for the Advancement of Science, Philadelphia, December 29, 1926.

ASTRONOMY

By Dr. FRANK SCHLESINGER
YALE UNIVERSITY OBSERVATORY

In planning this symposium our chairman has arranged in alphabetical order the nine sciences that we are to hear from, and so astronomy has the first word. This science has had the first word in a more important sense, for it not only shares with mathematics the distinction of being the earliest to be cultivated, but it stands alone as the first to be applied to the affairs of mankind; without its aid our ancestors of thousands of years ago would have found themselves at a severe disadvantage in their struggle with nature and with rival nations.

Astronomy touches our modern lives so rarely that few of us have anything more than the merest acquaintance with the skies. But centuries ago, before there were cities, *every* man knew the stars and their habits intimately. This knowledge had much to do with the esthetic and religious development of early man, but of this we are not to speak this morning, as we are for the moment concerned only with the relation of astronomy to industry. All early races have used celestial objects as timepieces centuries before any artificial device for the same purpose was invented. A mere inspection of the position of the sun by day and of the moon and stars at night can with practice tell us the time within a few minutes. These objects were also made to serve as calendars to tell how much of the year had elapsed and particularly to indicate when various crops were to be planted. This was done by noting the times of heliacal risings of certain bright stars. The sun in his apparent annual journey among the stars renders invisible by his brilliance for several months those that are for the time in the same general direction. The first morning that a bright star can be distinguished in the glare of the rising sun is the date of that star's heliacal rising, and to a faithful watcher it tells how much of the year has elapsed with an uncertainty of only a day or two. From these happenings, or from the corresponding heliacal settings in the rays of the western sun, were fixed the days of sowing, the best times for this having been determined through sometimes centuries of accumulated experience of a particular nation in a particular locality. This knowledge was transmitted by word of mouth from father to son for many generations, and constituted a priceless asset for the nation or the race.

To those who live by the sea and to those who merely live near the sea, the rhythm of the tides is still one of the most important things in nature. All primitive races must have noticed very early the intimate relation between the times of high tide and the position of the moon; and soon thereafter the connection between the fullness of the moon and the fullness of the tides must also have forced itself upon their attention; in other words, they could not have failed to notice that at new moon and again at full moon, the high tide is higher and the low tide is lower than during the intermediate intervals. These are important facts to those who must launch and beach even the smallest of ships, and this business is much facilitated if we can predict, as we can, the time and the nature of the tides from an inspection of the moon.

To such an audience as this I need hardly dwell at length upon the contribution that astronomy has made to commerce by providing the mariner with the means for telling where his ship is.

Without this help navigation would be confined to the dangerous and time-robbing necessity of groping along coasts. Without it important portions of the earth and their products would doubtless still have remained unknown to civilized man, and the whole fabric of the world's industrial organization would have been very different from what it actually is.

It is a curious fact that the progress of science has taken away from astronomy almost all its ancient opportunities to serve the industries. We no longer use directly the sun and stars as timepieces and calendars; and we no longer need to observe the moon to foretell the tides; all this information comes to us in the convenient form of printed almanacs. Even as a help to navigation, astronomy is no longer as indispensable as it once was, and it is, I think, soon to lose its place altogether as part of the mariner's equipment. The problem of navigating may be divided into three parts: the determination of the time at some standard port (usually Greenwich, in England); the determination of the local time; and the measurement of the latitude. Of these the first has until recently been the most difficult, but the broadcasting by radio on every sea of accurate time signals has made Greenwich time very easy of access and very certain. The perfection of the radio direction-finder, which even now is in a sufficiently well-advanced state to warrant its use, will probably in a few years render it unnecessary for ships to make use of any kind of astronomical observations or calculations.

But if the passage of time has deprived the astronomer of some or most of his ancient opportunities it has also provided new ways in which he can be of service to industry and engineering. You will not expect that these contributions will vie in number or importance with those that other sciences have offered, for astronomy is now farther removed from the affairs of men than any other science. We may distinguish between pure and applied chemistry, between pure and applied physics, between pure and applied geology and so on through the list. But we can not make a similar distinction in astronomy: it is all pure. Whatever contributions astronomy has made of the kind we are discussing have, as Wells expresses it, been thrown over the shoulder of an investigator who is intent upon a very different task. In the short time at my disposal this morning I shall not attempt to enumerate these contributions, even though the list would be a short one as compared with what might be compiled in other fields. Let me instead dwell for a moment upon a single instructive example, namely, that presented by spectrum analysis. Peculiarities in the light of burning elements were noted as early as 1753; during the century that followed, the foundations of the subject were vaguely sensed by many experimenters, but it was not until 1859 that the physicist Kirchhoff and the chemist Bunsen, working together, formulated the laws of spectrum analysis and put the subject on what we might call a production basis. In doing this they had recourse not merely to results in their own laboratories, but also of another in which the conditions were fortunately very different, namely, in the sun, and their deductions followed a comparison of solar and terrestrial spectra. It was thus from a happy combination of the findings of the astronomer, the physicist and the chemist that science and industry were put into possession of this new and powerful weapon. This partnership in spectrum analysis has persisted ever since; it has yielded, and doubtless will yield in the future, knowledge of the most valuable kind in every sense. A single example must suffice. In 1868 Lockyer, observing the spectrum of the sun's atmosphere, noticed a set of

bright lines which could not be identified in the spectrum of any known terrestrial source. He inferred that they must arise from an unknown element which he named helium. Nearly thirty years later this element was "run to earth" by the chemist Ramsay, who found Lockyer's lines in a Scandinavian mineral called clevite. Lately pure science has handed helium over to the engineer who, among other uses for it, fills dirigible airships with it and who has learned how to produce it in large quantities.

These few examples illustrate a truth concerning which I am sure you will hear again to-day. If we were to confine ourselves to those contributions that come directly to industry and engineering from a particular science, we should miss the best part of the story. Just as great advances are very rarely the product of a single mind, almost as rarely are they born and nourished within the confines of a single science. It is for this reason as well as others that the organization and coordination of scientific effort is of the highest importance, not only from the point of view of pure science but even more so from that of the industries. And pursuing this thought a step further, let us ask ourselves how long we should continue to keep up our rapid advances in industrial progress if for any reason the march of pure science were retarded. It was long ago wisely said that to bring up a youth properly you must start by training his grandmother.

BIOLOGICAL SCIENCE

By Professor HENRY B. WARD
UNIVERSITY OF ILLINOIS

In the childhood of the human race by man's contact with living things on which he depended for food and from which he manufactured clothing, tools and weapons, this primitive study of biology gave the impulse for the construction of traps, pens, pitfalls for capturing his prey and for primitive industries by which the materials obtained were more fully utilized. This fundamental relation of biology to industry has been maintained ever since. Terms such as horse power, work energy, fatigue, etc., owe their origin and their carrying power to biology. Wood and its products, a variety of fibers, leathers, bone, glue, oils, fats, creosote, rubber, charcoal, bone and a multitude of other materials, some long in use and others newly found, are the basis for countless industries and are essential factors in the work of the engineer. Biological studies on the structure, origin and physiological characteristics of such materials furnish a firm foundation for their utilization in industry and engineering.

The microscope is probably the most important instrument which industry and engineering owes to biology. From the simple lenses used by fourteenth century students of biology to the complex and powerful compound microscopes of the present the improvements have been developed in the effort to penetrate further into the intimate structure of living organisms and to approach nearer the solution of the problem of life.

The discoveries which enable man to control fermentation and to use sterilization enter into the processes of modern industry in an essential manner. These processes worked out

in biological research though more striking than others, represent a long series which have been contributed by biology to engineering. Even the data for the effective handling of flood prevention came from biological studies on root systems of plants and their relation to soil as well as on the types and habits of burrowing animals. In the solution of a great present-day problem, the protection of harbor construction against the shipworm (Teredo), the biologist and engineer work side by side. When the existence of the silk industry was threatened with destruction, the studies of the biologist furnished both the explanation and the remedy. Centuries of study of the flight of birds eliminated misconceptions and determined fundamental factors in form, plan of operation, relation to air-currents and other essential elements utilized in aeronautics and aviation.

Sanitary engineering is of all most deeply indebted to biology. The contributions to it in our own country of W. T. Sedgwick, the biologist, and of a host of others, have made possible modern processes of water purification and sewage disposal. Utilized on a larger scale by the engineer these developments of pure biological research are of inestimable value to the human race.

Preventive medicine, which is a product of biological studies, affords essential aid to industry and engineering. Hookworm disease in mines, brickyards and agriculture, malaria, yellow fever, plague and similar diseases no longer paralyze commerce or cripple industry. Their control worked out by biology makes it possible to maintain public health and build great engineering works in regions where a century back disease was rampant and the very existence of the community difficult to maintain.

CHEMISTRY

By Dr. CHAS. H. HERTY
ADVISER, THE CHEMICAL FOUNDATION, INC.

When some future student of our times evaluates the many services rendered the nation by Secretary Hoover I am confident that emphasis will be placed upon his appeal, as chairman of a committee of eminent men, for generous support from the industries for the prosecution of research in pure science. That was no idealistic appeal, but the direct outgrowth of a deep conviction that only through advances in pure science can industry hope to move forward at a continuously progressive rate. It is indeed striking that such a plea should come from the head of the great business department of our government. Whether the appeal proves completely successful is of incidental importance; one purpose is already accomplished—he has driven the thought home convincingly. That conviction can not fail to bring adequate response through one channel or another, unless, in the absorption of the everyday matters of our lives, we forget.

I take it that the function of this symposium is to assemble from all the branches of science a wealth of illustrations which may serve to keep the thought dynamic, that eventually it may be brought to abundant fruition.

Fortunately for my own responsibility here, the case of chemistry needs, perhaps, least elucidation. Within recent years there has developed among the chemists a group of popular writers—

Duncan, Slosson, Hendrick, Howe, Cushman, Free, Stieglitz, Hale, Harrow, Wendt and many others—who have given their time and talent to the presentation in attractive form of the story of chemistry in its relation to the manifold activities of life. Filled with appreciative knowledge of the dependence of industry upon pure science, this dominant thought is apparent throughout their writings.

Nor have we had to rely upon the random buying of books or the occasional glancing at publishers' announcements for the dissemination of such material. With the cooperation of many distinguished chemists, in the universities and in the industries, the Chemical Foundation has, by gift and by sale at actual publication costs, continuously developed an ever-widening circle of readers. No one can estimate the pervasive influence of the prize essay contest, founded as a memorial to their daughter, Patricia, by Mr. and Mrs. Francis P. Garvan, and conducted annually by the American Chemical Society in the secondary schools, public and private, throughout the nation.

Why, then, should I endeavor to augment what already has been so well done? One reason only—the full realization of how unevenly the processes of dissemination proceed and how necessary it is to repeat over and over again if we hope eventually to reach all.

But with the necessarily limited time at my disposal to-day, certain pertinent chapters must be chosen as illustrative of the prolific contributions of the science of chemistry to industry.

Much of our chemical industry was originally developed through pure empiricism, but the applications of new principles derived from pure science have revolutionized these industries and carried them forward with infinitely greater strides. Meanwhile, these same concepts have brought into being new industries which have enriched the world.

What branch of chemical industry is not indebted to John Dalton for his atomic hypothesis and to Avogadro for his supplementary conception of the molecule? What peace of mind could any manufacturer have if Lavoisier had not heralded the quantitative period in chemistry? Visit Niagara Falls and see the great electrochemical industries—then think of Michael Faraday and his fundamental concept. Watch the car loads of corn going into the great fermentation plants in the middle west or the tank steamers at Baltimore arriving with molasses, the waste product of Cuba's great sugar crop, then read the "Life of Pasteur."

In 1856 Perkin, seeking to prepare quinine from aniline, accidentally brought into existence mauve, the first aniline dye. It is not difficult to believe that had we been dependent on such casual methods alone progress in the field of coal-tar compounds would have been halting and uncertain. Kekulé in 1865, with his vision of the structure of the molecule of benzene, C_6H_6, changed the situation completely. The evidence marshalled to support his belief that in this molecule the six carbon atoms are linked to each other to form a closed chain made clear many facts which could not theretofore be explained. Of far greater importance, this concept of pure science presaged the discovery of many new compounds. Order was brought into the whole system of coal-tar compounds, and research on the production of thousands of these derivatives was feverishly stimulated. Upon the basis of this fundamental theory have grown our great coal-tar industries—synthetic dyes, medicinals, aromatics, flavors, photographic chemicals, high explosives and many war gases.

At the eighth international congress of applied chemistry, held in New York

City in 1912, Professor Bernsthen, of the Badische Anilin und Soda Fabrik, gave a lecture, with demonstrations, on the synthesis of ammonia from hydrogen and atmospheric nitrogen by passing the mixed gases over a catalyzer at increased temperature and pressure. He announced the laying of the foundations of the first plant for the manufacture of synthetic ammonia. This was the industrial application of the brilliant research in pure science by Professor Haber. As a climax to his demonstration, Professor Bernsthen held a piece of white cloth before the exit tube of the apparatus, and as the ammonia fumes touched the fabric it was rapidly transformed into an American flag which the professor enthusiastically waved before the audience. Little was it realized, as we applauded the striking phenomenon, that within a few years, as a result of this successful utilization of pure and applied science in Germany, thousands of American lives would be sacrificed as they followed that flag on the battlefields in France.

Not many years ago the producers of cottonseed oil in our southern states spent much time and money on fruitless efforts to persuade the housewives to substitute this liquid fat for lard, the semi-solid fat of the hog. Meanwhile, in the quiet laboratories of a French university, Sabatier and his co-workers were deeply engrossed in a pure science study of the transformation of unsaturated to saturated organic compounds. Sabatier showed that the addition of the necessary hydrogen atoms could be readily effected by the use of finely divided nickel as a catalyst. Cottonseed oil is a mixture of glycerides of unsaturated fatty acids. On hydrogenation by Sabatier's method there resulted saturated compounds which were solid. Then by careful regulation of the hydrogenation process a semi-solid fat, a true synthetic lard, was produced. The prejudices of the cook thus overcome, a great new industry was created, and again pure science had made industry its debtor.

While organic chemists were absorbed in developing the many new lines of work suggested by Kekulé's views, there appeared in the Transactions of the Connecticut Academy of Sciences, in 1876, a contribution so cloaked in mathematics that chemists did not realize that Willard Gibbs' phase rule was an epochal addition to chemistry. When years later it became understood, its application brought clarity and scientific basis to many processes which previously had been purely empirical. Industrial applications were rapidly made. The whole field of alloys, particularly that great tonnage alloy, iron and carbon, took on a new light; the problems of Portland cement became clarified; and in a multitude of other lines this fundamental research proved of inestimable value.

Sometimes, however, the worker in pure science is discouraged by seemingly unfortunate properties of the material with which he works. So in 1872 Baeyer found that phenol and formaldehyde formed a condensation product, but it was not crystalline. He saw no attraction in study of the gummy, resinous mass. Baekeland, however, boldly attacked this problem, and created the new synthetic resins, the uses of which seem to be unlimited.

The beautiful finish on our automobile bodies to-day is an illustration of the complete revolutionizing within the last few years of an old, established industry, that of lacquers, made possible by the work of Whitaker and his research staff in the U. S. Industrial Chemical Company. All accepted methods for making ethereal salts, such as ethyl acetate, involved high concentration and a dehydrating agent. This meant high cost, for the available acetic acid varied below 15 per cent. concentration. Whit-

aker resolved to put his whole staff on a pure science study of the question of esterification. Rates of reaction between alcohol and acid, equilibrium conditions, concentration of catalyzers, and similar problems were thoroughly studied. To quote his own words: "Months were required to complete these investigations, but the facts once established presented an entirely new view of the problem, saved months of time spent on mistakes, or perhaps avoided final failure." The net result of the work was the installation of a continuous process for esterification of dilute acetic acid, from which there is produced a monthly output of 150,000 gallons of chemically pure anhydrous ethyl acetate.

In the preceding illustrations, mention has repeatedly been made of the use of a catalyst, a substance which affects markedly the rate at which chemical reactions proceed, without itself being affected by the reaction. Here the purest of pure scientists have been gross empiricists. Catalysts have been used for many years, but the selection of the proper catalyst has been the result of haphazard discovery or the application of the "cut and try" method. Yet we are dealing with one of the fundamental principles of chemical reactions, and, from the standpoint of industry, with one of the greatest dividend-paying agencies. Shall we rest content with empiricism? Do we not know, from all other experience in matters chemical, that when once we understand the scientific explanation of catalysis we may look forward with confidence to the opening of entirely new chapters in chemistry and its application?

Fortunately Langmuir has brought some light into this all too clouded field. To-day Princeton University, through the work of Hugh Stott Taylor, has become the center for the scientific attack on this problem. It is a sad commentary that, in this period of construction of magnificent chemical laboratories in our universities throughout the country, Taylor's work must be carried out in the old and dingy basement of a laboratory utterly inadequate and ill-suited to the needs of a great university.

This thought brings me to a fundamental question: "How should research in pure science be supported?" Are most favorable conditions for its successful prosecution to be found in our universities, in the research laboratories of our more progressive corporations, or in endowed institutions?

The resources of the universities, whether derived from taxation or endowment, are frequently too limited to provide adequate equipment and sufficient associates to ensure the maximum output of men of fine talent, and too often their research is spasmodic, interrupted by teaching duties and administrative responsibilities. Yet research work under the influence of a noble teacher, and within the walls of a great university, is inspiring. From this source, too, must come the supply of well-trained research workers.

The seductive allurements of the larger salaries offered in industrial work have so depleted our university staffs that industry is at last awakening to the short-sightedness of this policy. That is the solid foundation on which rests the appeal of Mr. Hoover's committee. The successful culmination of their plan for support by the industries of university research in pure science, to the extent of $2,000,000 annually for ten years, would restore the equilibrium.

One can not but rejoice in the awakening of the petroleum industry, as evidenced by recent contributions to aid fundamental research in the pure science hinterland of that industry. Under the direction of the American Petroleum Institute, problems suggested by a group of scientists are being assigned to those workers in university laboratories whose

experience and equipment seem best to meet the needs of a particular study.

From the research staffs of industrial laboratories contributions to pure science will continue to be received. It is a wise investment for a corporation thus to make sure that it will be the first to realize upon the practical application of a new development in pure science. Yet research in pure science will always necessarily be of secondary importance in an industrial organization.

From privately endowed research institutions we have a right to expect real contributions to pure science. Their staffs are not under the seeming necessity of frequent, and therefore often premature, publication as offering the best means for preferment; nor are they under the pressure of making an immediate showing to directors more interested in the treasurer's balance sheet than in the report of the director of the research laboratory.

Excellent as have been the results from all these existing agencies, the fact must be faced that in none of them is the matter of research in the pure sciences the primary purpose and goal of the organization.

I remember well my last talk with the late beloved Dr. Wallace Buttrick, of the General Education Board. He had been besought to recommend financial aid to an undertaking in a rather restricted field of scientific research. He told me that he couldn't get up any enthusiasm for the proposal, that more and more he was coming to the conviction that funds should be found for creating a great institution where our ablest scientists could carry on fundamental research in all branches of science under conditions as nearly ideal as could be furnished. That was the ripened judgment of a man who had given the many busy days of a long life to aiding every form of education and research. His thoughts were always progressive; his feet always upon the ground.

If Dr. Buttrick was right, and I hold that he was, where should support for such an undertaking be sought? Granting as axiomatic that progress in applied science is strictly delimited by the advances in pure science, who would profit most? The answer is—each and every one of us. Not the manufacturer, except incidentally. Witness the constantly lowered cost to the consumer of electric lighting, of automobiles, telephones, aluminum and a host of other commodities.

If, then, we the public are the chief beneficiaries of the advances in pure science, it behooves us as thrifty citizens to busy ourselves with the problem of providing those ideal conditions which will ensure the maximum output which the human brain is capable of producing.

How can such collective action be taken? By federal taxation and Congressional appropriation of funds adequate for the creation and maintenance of a national undertaking where ideal conditions for research in pure science, both as to personnel and equipment, will be afforded.

I know full well the many objections to such a proposal which arise at once in your minds. Of course the next Congress would not appropriate funds for this purpose. Naturally politics would make itself felt in such an institution. Governmental red tape would certainly be restrictive on originality. These, however, are conditions of to-day. I am not of those who scoff at Congress. Our representatives in Washington, I believe, endeavor to carry out faithfully that which they are confident is for the best interest of the whole nation. They fairly represent the average thought of our people.

My proposal is based upon the as-

sumption that the men of science will during the next few years carry on an even more intensive campaign of popular education which will result in each citizen seeing clearly how much he has at stake in this matter. Confidence in the reasonably early success of such an educational undertaking is begotten of an intimate knowledge of the ways by which our people have so quickly grasped the facts of the close relation chemistry bears to their everyday lives. That was no miraculous revelation, but the result of the thoughtful, earnest, self-sacrificing work of many men who deemed it primarily a duty to their country—and they have gotten a lot of fun and happiness out of doing it.

With a nation thus aroused as to the determinative influence pure science has on human advance, Congress could not fail to heed the popular demand that an adequate part of the country's taxes be appropriated for this worthy purpose.

ECONOMICS

By Professor JOSEPH H. WILLITS
UNIVERSITY OF PENNSYLVANIA

In 1886, Henry R. Towne presented his address on "The Engineer as an Economist" before the American Society of Mechanical Engineers. In this address he may be said to have first given the fact that engineers and others who became industrial managers deal not only with problems of materials, machines and power, whose roots lie in such fields as chemistry, physics and mathematics, but also with such problems as cost, value, price, markets and labor, whose roots lie in whole or in part in the field of economics. That thesis has been so frequently repeated from innumerable pulpits, in the literature of the field of industrial management and by the increase in student enrolment in courses that include work in theoretical and applied economics and in a thousand other ways that its repetition here amounts to an unnecessary dwelling upon the obvious. To state the contribution adequately would require a book of many pages; one must needs in the space allotted for this paper limit the discussion to general statements with only a few illustrations.

One hesitates to use the method of analogy in view of the pitfalls of that method. With the hope that my audience, however, will recognize that no man's analogy should be followed to all its logical conclusions, I will resort to such a method in stating the general contribution of economics.

The development of ocean transportation has contributed much to the world in extending the area of our commercial interdependence, in extending the range of our intellectual interests and in promoting understanding and unity among peoples and nations. In making possible this development of ocean transportation we may distinguish three chief sources of contribution as follows:

(1) All the work of the scientists and the craftsmen whose labors have contributed directly or indirectly to the development of the technique of shipbuilding so that from the dugout of the savage there has evolved the modern *Leviathan*.

(2) All those practical seamen—those operators of ships—whose practical problems and experiences have been written down either in the log-books of

their ships or the mental log-books of their craft. Their contribution has been a contribution of practical seamanship.

(3) But ocean transportation would not have fared well and would still remain a precarious venture had we developed nothing beyond marvelous ships and fine old "sea-dogs" as captains. Our confident steering on a fixed schedule over all the oceans of the world could never have come about without a third contribution—the contributions made by that long series of scientists—which led to the development of the laws of navigation. The scientific studies which made possible the development of the technique of shipbuilding and the laws of navigation reduced the emphasis on empirical seamanship and lessened our dependence upon those romantic and daring figures "who braved the unknown seas." In the words of Kipling:

Our dial marks full steam ahead,
Our speed is timed to half a turn.
Sure as the tidal trains we ply
Twixt port and port. Romance, good-bye!

But in place of romantic, heroic, empirical seamanship, we have a science (and an art) of navigation.

The world is similarly engaged in the evolution of a science (and an art) of industrial (or business) management. The contribution of economics—theoretical and applied—is a contribution towards the development of laws of navigation in the industrial ocean. Developments in the industrial field are not analogous to developments in the field of ocean transportation in at least one respect. In ocean transportation, the laws of navigation were evolved in advance of any considerable development of the technique of shipbuilding. When therefore the developing needs of the world called for much transportation of goods and people by sea and when large ships had been developed for such service, the world already knew how to navigate such boats.

But another condition obtains in the industrial world. As a result of the applications of scientific discoveries our whole industrial machine has grown almost overnight to proportions that dwarf the most complex *Leviathan*—entirely too rapidly, for there to have been any corresponding development of laws of navigation in the industrial world. In industry, our knowledge of "where to steer" has not kept pace with our knowledge of "how to build the machine." In industrial management, we are still midway between the stage of high-grade empirical seamanship and a science of navigation. To put it another way, we know how to manage machinery and we know how to use materials, but we are still in the elementary stage of learning many of the fundamentals to effective administrative steering which are involved in the managing of men, of finances, of markets and of production. Just as the contribution of the physical sciences was essential to the development of the industrial machine and of our understanding and use of materials, so is the contribution of economics and the various related social sciences fundamental if our colossal industrial machine is to be effectively administered and wisely controlled in the interest of all. In the words of the late Alfred Marshall, "The need for such guidance in the practical conduct of life was never as urgent as now."

The experience and records of individual business enterprises and individual managers of industry constitute the log-book of each enterprise. This log-book is concerned with the individual experiences, problems and deviations from course of that enterprise. The economist is concerned with the principles which determine the general course

in contrast with the details which determine individual fluctuation. The economist is interested in the long run and from the facts derived from a multitude of industrial log-books and other sources seeks the general cause or tendency. He is also concerned in the social or national effect of such general tendencies. To quote Alfred Marshall again, "Economics aims to gain knowledge for its own sake and to obtain guidance in the practical conduct of life, and especially social life." And further, "It aims . . . at helping to determine not only what the end should be but also what are the best methods of a broad policy devoted to that end." "But though thus largely directed by practical needs . . . it shuns many . . . issues which the practical man can not ignore; and it is, therefore, a science, pure and applied, rather than a science and an art."

But these philosophical comments upon the nature of the contribution of economics leave one with only a vague conception of that contribution. One may distinguish four major forms of contribution, as follows:

I. "The Definition and Scientific Study of Phenomena and Problems in Economic and Business Life."
II. "The Training of Research Workers for Industry."

Of a less direct character but of equal importance, we may distinguish the following:

III. "Education for Administration in Industry (and Business)."
IV. "The Education of Public Opinion and The Elevation of the Standard of Business Ethics."

I. The Definition and Scientific Study of Phenomena and Problems in Economics and Business Life

There is not an aspect of the big fields of economics or of industrial life to which an important contribution has not been made by students of economics. I will cite but one example of that contribution—the contribution to an understanding of the so-called "business cycle." Industry has always been a prey to recurring cycles of business depression. Until the economists undertook careful scientific analysis, the business cycle was regarded as a single phenomena occasioned by many curious causes of which sunspots may be taken as an illustration. The analysis of crises, beginning a hundred years ago and continuing with increasing thoroughness as scientific methods and quantitative data were developed, has revealed that there is not one business cycle but many business cycles, one for each industry or trade and even for each individual business. It has been revealed that each cycle may be broken down into its four periods—revival, prosperity, crisis and depression; that each period has its own definite characteristics of economic activity, of prices, of money rates, of credit conditions, of labor disturbances and related matters. When to the results of these analyses there was added the possibility of reliable statistical measurement of the cyclical movement, the way was open for a complete breaking down of the cycle into its constituent trends and details. With these developments, the possibility of industrial adjustment to that multitude of trends and conditions which is roughly described as the business cycle became possible. There could be no problem of business forecasting so long as all the factors were considered as one unit. But given the scientific analysis which I have briefly described, the world bloomed with efforts by individual companies, by whole trades, by financial institutions, by government bureaus and by business services to forecast business activity or a particular corner of business activity and adjust policies accordingly. These efforts were and are crude. The path

was, is and inevitably will be strewn with the tragedies of damaged reputations. But evidence is conclusive that we have made progress towards control of the fluctuations in business activity. The imagination is challenged by the possible future contributions to general business stability, to enlightened industrial management and to the release of the human race from the fear of unemployment.

What many economists under the leadership of Professors Wesley C. Mitchell, Charles J. Bullock and Warren Person have accomplished in the fundamental analysis of the business cycle might be duplicated in almost any field. The work of Commons, Pigou, Hoxie and Bezanson in the field of industrial relations; of Johnson in the field of railroad transportation; of Tryon in the field of the economics of power; of Seligman and Kemmerer in public finance; of Marshall and Taussig in economic theory; of the National Bureau of Economic Research in income; of Huebner in insurance and of all economists in defining the concept of production as distinguished from that of mere trading—all are only illustrations of the service performed by economics in analyzing those fundamental phenomena which are too complex and obscure for the individual industrial manager to assay alone, but with which his daily decisions must be in adjustment if he is to manage wisely.

II. The Training of Research Workers for Industry

This contribution is always a major contribution of science to practical life. A census of the heads of departments in industry devoted to research in economic, financial, commercial and industrial problems would reveal an overwhelming percentage of men who had had graduate work or had taught in these fields at universities. Leonard Ayres, of the Cleveland Trust Company, Stewart, of the Federal Reserve Board, Berridge, of the Metropolitan Life Insurance Company, Parlin, of the Curtis Publishing Company, Lincoln, of Western Electric, and B. M. Anderson, of the Chase National Bank, are only a few of the more familiar examples.

III. Education for Administration in Industry (and Business)

The expansion of industry during the last hundred years—even during the last fifty years—has been so tremendous as to amount to a revolution. Eighteen seventy-five was literally ancient history from the standpoint of modern business development. As David Houston has pointed out, greater changes have occurred in that period than occurred in the thousand years preceding. And one of the important results of these changes has been the demand for a larger amount and a higher quality of talent for industrial administration than the world had ever before needed. The direct educational response to this demand can not be included in the category of a pure science. But next to experience, economics contributed most fundamentally to this shifting of talent. It supplied the fundamental studies upon which education for business and industrial administration had to be based; it supplied that material in the form of textbooks so as to make education generally possible; and it supplied—inadequately, it is true—but nevertheless supplied, most of the demand for teachers in these new fields. This contribution could never have been made without the underlying scientific labors of all the deductive and inductive workers in the field of economics. Without them our business schools and our courses in industrial engineering could never have come into existence.

IV. The Education of Public Opinion and the Elevation of the Standards of Business Ethics

The theoretical and applied workers in economics were doing more than educate college boys who might some day become managers. With their scientific studies, their text-books and their teaching, they were educating an entire population to some measure of understanding of the problems and phenomena of the new world in which we had so suddenly found ourselves. Negligible though that understanding still is, it is extraordinary compared with that of a quarter century ago. To-day, therefore, the acts of industrial leaders are carried on before an audience increasingly interested and informed on industrial problems. One result of the greater public understanding and of the university education in management and administration has been to bring more and more of the professional spirit to industrial management. With the development of that professional spirit has come an elevation of ethical standards so that the business standards of the eighties would not be countenanced to-day.

With all these shifts in the problems confronting us and in the tools available with which to meet problems, it is not surprising that we are witnessing a shift in the type of business or industrial manager. In the epoch which we are leaving, the industrial leader was a man who did not consider risks too carefully, who used figures sparingly and played hunches. It was the type best fitted to survive, for we needed seamen, not navigators.

To-day our emphasis is shifting to the leader who is a careful planner, a skilful, thorough organizer who disregards hunches and assembles and studies the facts before making a decision. We are demanding industrial navigators who are familiar with the laws of industrial navigation.

GEOLOGY

By Professor HEINRICH RIES
CORNELL UNIVERSITY

It is of interest to note that the science of geology which may be said to have originated not more than two centuries ago in the vague speculations of the cosmogonists, and which became well organized only within the last century, has within the last thirty or forty years been found to have such wide practical application that there has developed a well-marked and clearly recognized branch called economic or applied geology.

But although the practical applications of geology were not widely recognized at an early date, there is no doubt that its early development, even as a pure science, was partly in response to the miner's desire for accurate information regarding the occurrence and distribution of mineral deposits. Happily the benefits derived in this case were not all on one side, for the geologist in turn profited much by the information obtained from the sections of the rock formations exposed in mining and quarrying. Indeed, the detailed study of mineral deposits has sometimes aided greatly in the solution of many fundamental geologic problems.

Lyell in his classic work, "The Principles of Geology," has drawn attention to the fact that the contribution of different nations to geological science depended not alone on the genius of the

individual workers, but also to a large degree on the peculiar geologic environment of their fields of labor.

And so while we may say that because of these conditions mineralogy received a strong impetus in Germany, stratigraphy in England and paleontology in France, I think we may add that economic or applied geology has developed in the United States on a larger scale than in any other country, due to our important mineral resources and industries which cooperate closely with geology.

The increasing attention which applied geology has received from geologists has also been reflected in published writings, for, as pointed out by A. H. Brooks,[1] there were in 1890 less than 1 per cent. of the publications of the United States Geological Survey devoted to applied geology, while in 1910 98 per cent. of them treated of this phase of the science wholly or in part. The same has been true of other countries where geologic work has been carried on.

No better illustration of the importance of applied geology and its relation to industry can be given than to point out the well-recognized fact that mineral resources are an important factor in a country's development. The lure of gold and other metals has attracted thousands into new territory, while the search for oil has carried exploring parties into all parts of the world. When once the deposits of these useful materials are found and developed, railroads are built, towns may spring up and other industries take root. And so the development of industries based on mineral products and the carrying out of great engineering projects, whose completion has involved the solution of geologic problems, have not only stimulated the development of applied geology, but involved its close cooperations with engineering and industry.

We can therefore mention at least three ways in which this branch of geologic science makes itself useful. (1) Geologic knowledge is essential in the intelligent search for and valuation of mineral deposits; (2) the application of geologic principles to practical problems in engineering and other industries is often helpful; and (3) the geologist and mineralogist have by their investigations of the properties of the natural inorganic compounds found in the earth's crust accomplished much fundamental work, on which the chemist and physicist have built.

Some of the applications of economic geology deserve more than passing mention.

Water Supply

With the tremendous growth of some of our cities the engineer is sometimes forced to go long distances in order to obtain suitable and adequate supplies of water. Projects involving the construction of large storage reservoirs, dams and many miles of aqueduct tunnels or trenches to hold pipe lines are undertaken.

Here then he may be confronted by geologic problems from start to finish, several of which may be mentioned.

The selection of a reservoir site needs to be more than topographically correct, since it must also be watertight, and we have to consider such geologic features as the impermeability of the surrounding rock formations and the level of the water table around the proposed location. The question of silting up by the inflowing streams is a further matter which can not be neglected.

Similar geologic problems present themselves in the selection of a dam site.

No less important is the consideration of geologic features where an aqueduct is carried below ground in pressure tunnels, for its permanence and tightness

[1] *Jour. Wash. Acad. Sci.*, Vol. II, p. 19, 1912.

depend on the tightness and solidity of the material tunneled through. Permeable strata, water-bearing beds, crush zones due to folding and faulting and buried river channels are among the geologic phenomena which may cause no end of trouble for the engineer, unless he knows of their existence in advance.

The successful completion of one of the greatest engineering works in the United States, the Catskill aqueduct for New York City, which encountered all the above-named troubles, has emphasized the great advantage to be obtained by the proper coordination of geologic and engineering investigations. The experience gained here in the application of geology to engineering problems should serve as a splendid example to be copied many times in the future.

A second phase of water-supply work to be considered in this discussion is that of artesian supply, for not a few cities and rural communities are dependent on driven wells.

No water supply engineer, familiar with rock formation and structure and their relation to water supply, would assume that granite and sandstone were equally valuable as aquifers, or that because one region supplied an abundance of water to wells driven in glacial drift, it was possible to get a similar supply from another drift-covered area, even though the rainfall were the same at both localities. Geology has shown that certain rock structures and certain rock types are much more favorable as regards their water yielding capacity than others, so that a fairly reliable forecast can be made of what is to be expected in a given region, where the geologic conditions are known.

Railroad Construction

Here again geologic problems confront us. In driving tunnels through mountain ridges, we can not overlook the structure of the hill to be pierced nor material composing it.

The reports on the long tunnels driven through the Alps make most interesting reading, and emphasize clearly the benefits to be derived by cooperative work between the engineer and geologist. It is interesting to note that even in that region of highly folded strata the calculations and predictions of the geologist checked very closely with the facts as found by the engineer.

This however by no means ends the geologic problems that may arise in railroad construction, all of which may affect either cost or stability of road. These would include investigations of materials underlying depressions, danger from landslides, zones of faulting, relation of rivers to bridges, while in some regions, like Alaska, even glaciers can not be ignored, as by their advance or retreat they may directly or indirectly seriously threaten lines of rail communication. Perhaps equally important also is the investigation of new territory as to soils and mineral resources, which can yield business to the railroad.

Miscellaneous Applications

Other examples of the relation of geology to civil engineering work might be discussed did space permit, but all that can be done here is to call attention to the need of considering rock types and foundation characteristics in road construction or of the bearing of a knowledge of stream action and wave work on river and harbor improvement.

The cause and possible prevention of landslides is another fruitful subject for consideration, and the troubles which they gave in the construction of the Panama Canal and at other localities serve to emphasize the need of being on the lookout for similar troubles elsewhere.

No less important is the problem of land subsidence caused in most cases by mining operations, but, by its upward spread, giving rise to serious surface disturbance. Much attention has been

given to this matter in Europe, and more recently in the United States. Many data have been obtained on the relation, nature and structure of the rocks to the direction and speed of the movement.

Military Science

A somewhat new departure in applied geology which has rendered conspicuous service in various ways in military work was that developed during the late World War. The selection of camp sites and the location of trenches and dug-outs were made with respect to geologic conditions when this was possible, while the location of the water table, as in northern France, had an important bearing on the obtaining of water supplies and the operations of mining and counter mining.

Mapping

The making of a map is regarded usually as a purely engineering task, and while it is so to a considerable extent, nevertheless it is well to remember that surface topography is always the result of geological processes, and a geologically trained engineer can interpret this knowledge from a topographic map. If therefore we have some understanding of the foundation of our map, it can not fail but to assist us in giving our topographic features a "more intelligent look." Comparatively minor features, which may seem of no importance if their cause is not understood, can be properly emphasized if the reason for their being is known, thus making the finished product of the surveyor more valuable.

In this field, however, the geologist has been greatly helped by the aviator, for the introduction of airplane surveying has not only given us an accurate means of mapping surface features for exploration and geologic work, but has also resulted in a saving of much time and money.

Metal Mining

The relation between the geologist and the ore miner has been most intimate since each one has helped the other.

The perplexing problems presented by broken and displaced ore bodies call for careful geologic work in their solution, since the all-important point to be settled is where the ore has gone. The study also of the origin of ore deposits has thrown much light on their mineral composition, shape and extent, which assist in the operations of exploration, valuation and mining. We should not overlook either the results obtained by a study of the peculiar phenomenon of secondary enrichment, which it has been found affects certain metals more than others and represents a process to which some of the important ore bodies owe their workable richness at the present day.

Coal

It has been said that coal mining was the first branch of industry to which geology made itself indispensable[2] in mapping coal fields, tracing the beds, working out the thickness, number and quality, and other features of importance. In many regions the structure of the coal measures is relatively simple, but in certain ones of more intricate structure, the importance of geologic work becomes noticeable.

The world's geologists have performed a useful service in estimating the reserve tonnage of the different ranks of coal in the several coal fields of the world, and in the United States the federal geologists have prepared a map showing the areas underlain by coals workable under present conditions of mining and of

[2] Watts, W. W., Brit. Assoc. Adv. Sci., Toronto, 1924, p. 91.

those areas under which the coal lies too deep to be workable at the present conditions.

Oil

This mineral resource stands next to coal as a source of energy, and forms the basis of an industry which has shown tremendous expansion, due to the fuel value of petroleum, the use of which can be said to have revolutionized some branches of engineering practice. In response therefore to an ever-increasing demand, there is going on a world-wide search for new sources of supply.

Since oil reservoirs do not outcrop, the geologist has a less easy problem than in his hunt for coal.

Geologic knowledge, keeping pace with industrial development, has pointed out so clearly what the most probable structures are that seem favorable for oil accumulation that the oil companies carry a staff of geologists, whose exploration work involves a direct application of geologic principles.

Agriculture

While our thoughts may naturally turn to civil and mining engineering when the practical relations of geology are mentioned, there are other lines of human activity with which it cooperates.

Agriculture is an industry which is closely related to geology, for the soils which support the crops and on which the latter depend for food are to be regarded as rock types. Indeed, in making soil surveys, the classification of soils is based largely on their origin and so geological knowledge comes to the aid of the soil surveyor. This is more particularly true in glaciated areas like the northern United States, where the surface materials are largely of glacial origin. Familiarity, therefore, with glacial deposits and their physiographic character and relationships are most useful in soil mapping. The application of the principles and processes of weathering may also help to a better understanding of the soil and the formation of soil colloids.

Chemical Industry

Chemistry and geology are mutually helpful. Various chemical industries consume large quantities of raw mineral products, but since these vary in their purity and composition, it is important for the chemist to be familiar with the irregularities of composition which the different types may show, because he is often called upon to pass judgment on new sources of supply. Here geology helps the chemist. On the other hand, the laws of physical chemistry which the chemist has worked out are of great assistance to the geologist in explaining many geologic processes.

Electrical Industry

In the study of mineralogy, much knowledge has been gained of the internal structure of crystals and their relationships, so that when the physicist began the study of crystal structure by means of the X-ray, he received from the mineralogist the results of much preliminary work that served as a basis for his further study. A very important advance due in part to the study of crystal structures has been the development of permalloy, whose use in submarine cables, as is well known, has greatly increased the speed of transmission of messages.

Political Geology

Many of the most important industries of a nation are based on mineral products, this being true during times of peace or war.

That nation, therefore, which possesses or controls the greatest variety and reserves of mineral wealth enjoys a position of major economic importance,

which becomes an asset of incalculable value in time of war.

This was emphasized during the recent world conflict, and indeed it has not been overlooked in the past when the different nations of the world have been expanding their possessions, since they have not been blind to the possible mineral wealth of the territory whose annexation they sought.

It brings to the fore a branch of geologic science which has been called political geology, and the careful planning to acquire lands whose mineral resources are essential to important industries has been aptly referred to as the strategy of minerals.

To take one simple and clear case, reference may again be made to petroleum, for as already stated a world-wide search is being made for new fields, and the reason is simply that it represents one of the most valuable mineral resources known. That nation, therefore, which controls the greatest reserves occupies an enviable economic position.

The United States is at the present time the greatest oil producer, but we may question whether it has any longer the largest reserves. We have used our oil more or less wastefully, we have placed no ban on free exportation and we have been generous in allowing the nations of other countries to come in and exploit our oil supplies. Unfortunately, the last is a privilege which is not permitted us in all other countries at the present time.

Although the United States is at present the dominating nation in production, its consumption is greater than its output, and it is not unlikely that in the future there will be important shifts in the centers of world production.

Leith[8] has remarked that the more immediate problems are: (1) Whether the discovery and winning of oil can be made to keep pace with the enormous acceleration in the demand, and (2) the adjustment and financial control of oil resources, the possession of which is becoming so increasingly important to national prosperity.

Going on down the list of mineral resources we find that certain countries are far from independent industrially, while others are partially so.

The United States hardly dominates the world situation in anything except copper, and even here is not so important as formerly. She has, however, an exportable surplus of a number of mineral products, but is dependent on foreign sources for cobalt, nickel, platinum, tin and to a major extent for, asbestos and potash.

Great Britain, to quote an additional case, controls extensive mineral wealth in her colonies, but within her own borders lacks many essential mineral products.

These two instances, and others, serve to emphasize the marked degree to which different nations are dependent on each other.

Conclusions

From what has gone before it should be clear that geology is of service to man in two general ways. The first of these is in exploring and evaluating the mineral resources on which industry and civilization are built, and the second is the application of geologic principles to various lines of human activity, such as engineering, agriculture, chemistry, etc.

Both of these are phases of economic or applied geology, but neither could be developed before geology as a pure science was more or less firmly established, and in this process it freely acknowledges its indebtedness to some of its older sister sciences such as chemistry, physics, botany and zoology.

It furthermore indicates the close relationship which must exist between the different sciences, a connection so close

[8] "Economic Aspects of Geology," p. 180.

that one can hardly consider them as sharply separated from each other. In a similar way they are all in their practical phases at least closely related to the different branches of industry, ready to serve them in every way possible.

MATHEMATICS

By Professor GILBERT AMES BLISS

UNIVERSITY OF CHICAGO

SOME time ago your chairman asked me to prepare for this meeting a few remarks on the contributions which the science of mathematics has made to the industries. The subject is one which has a great interest for me, and I will try to give to you the impressions of a so-called "pure mathematician" with regard to it. Let us understand at the beginning that I believe the term "pure mathematics" to be a misnomer. It is true that mathematicians sometimes have prided themselves on their devotion to theories far removed from the contaminations of any sort of uses in other fields. I can sympathize with them to some extent, because the uncertainties of the physical or other bases for applied mathematical theories, combined with the vagaries of inexperienced mathematical reasoners, do sometimes together make what seems to the pure mathematician an awful mess. If experiences of the past are to be credited, however, it is from these messes that truth may be expected finally to emerge, whiter and more brightly shining by contrast, and not infrequently clad in the raiment of pure mathematics. Much of the product of pure mathematical research of the past has already been put to use in some domain or other, and much more will in time find application. For this reason, as well as for others which may be equally defended, it is the duty of the pure mathematician to have results in his science at all times well ahead of the applications, and on a par with the products of other sciences which are still unused but which may be in demand at any time to meet unexpected industrial needs.

For the purposes of the present discussion two types of applications of mathematics may be distinguished. There are in the first place applications of the commonplace everyday sort, based upon elementary arithmetic or algebraic or geometric principles which every educated person is supposed to know or which he can "pick up," as they say, for himself without serious difficulty if he is sufficiently interested; and there is a second less elementary sort of application which can be devised or understood only by those who have studied farther into mathematics more seriously and thoughtfully. We shall see later that the calculus constitutes a rather definite intellectual and psychological barrier between these two types of applications.

Of the first type, I shall not have much to say. You probably did not come here to hear about them, and I shall not detain you long in speaking of them. But their importance in our modern civilization is undeniable. We all recognize the slowly rising tide of dissatisfaction with non-metric systems of measurements, or at least we have experienced in our travels the inconvenience of business transactions in a country in whose monetary system the first two decimal points represent twentieths and two hundred fortieths of a unit instead of tenths and hundredths. The economic waste of bookkeeping in

pounds, shillings and pence must be large indeed. But what would become of our present economic structure if we had no Arabic but only Roman numerals with which to carry through our arithmetical operations? What would become of a highly organized and complicated manufacturing or merchandising establishment handling hundreds of thousands or millions of units per year, with a delicately adjusted system of cost computing and accounting without whose accuracy neither success nor failure could be accurately predicted or measured. The answer is easy. Nothing would become of such an economic structure or of such a business establishment, because without the operations of elementary mathematics, as we now understand and use them, none such could ever have been developed.

These remarks have a certain triteness. We all recognize the indispensable significance of arithmetic and other forms of elementary mathematics in our daily life. The aspect of the matter which really needs emphasis, however, is that there is no mathematical process, either elementary or advanced, which is not the product of mathematical research in some bygone age. We are in the habit of accepting the subject-matter of our elementary curricula as property whose acquirement puts us under no obligation and demands from us no expressions of gratitude. But the most casual examination of the history of mathematics reveals the mathematicians of the past struggling with arithmetical notations; struggling to introduce and interpret the decimal point and the symbol zero after the other digits had been invented; struggling to develop operations of addition, subtraction, multiplication and division suited to the mechanisms of their respective methods of writing; struggling to operate with fractions by reducing them all to a common numerator unity instead of to a common denominator as at present; struggling to find the ratio of the circumference to the diameter of a circle; searching, seeking, investigating for our benefit just as we must constantly continue to do in our own epoch for the benefit of future generations if we would maintain our respect for ourselves as participants in the forward development of the human race. I have said already that a large part of the product of the mathematical researches of past generations has already been put to practical uses. Some of this product was at the beginning the response to economic demand, but much of it was the work of investigators who were spurred to activity by pure love of science and the applause and appreciation of their fellows. Let us see to it, if possible, that our own civilization appreciates and supports adequately the pure scientist, for if we do not do so progress will presently cease and we shall be regarded by men of the future as a selfish, self-centered, materialistic race.

I have spoken briefly of the applications of elementary mathematics in everyday life. Much more could be said upon this subject if there were time to do so. But there is not, and we may well turn our attention therefore to applications which are of a less elementary sort.

I suppose there is no plaintive request which is made more frequently to mathematicians by persons who have completed the formal processes of their education and entered actively into careers or professions of some sort, than the request for an elementary, and especially a short, presentation of the principles of the calculus. There is in fact no very easy road to an understanding of the calculus, though I hope and believe that ways can be found and books can be written which will make its principles much clearer and more readily accessible than they are to-day. The

great advances in the science of mathematics have been the product not of individual workers alone but of periods and schools. The roots of modern mathematical analysis reach back to antiquity, but the period of greatest activity in the developments of the elements of the calculus was the seventeenth century, and the great spokesmen of that period were Newton and Leibniz. At that date the fundamental principles of the theory were none too clear, and misunderstandings gave rise to many derogatory comments and lively scientific discussions. It was remarked by one of Newton's contemporaries that his new theory was a remarkable and brilliant piece of work, but that it would very likely never be thoroughly understood and appreciated except by persons imbued with unusual scientific interest and intellectual curiosity, a line of talk which is astonishingly like the comments on the theory of relativity which we hear to-day.

Very soon, however, it became clear that the new science would have a far more extensive application than was at first anticipated. During the eighteenth century the Bernoulli brothers and Euler, in Switzerland, and Lagrange, in France, formulated in terms of calculus notions a new theory of mechanics, and another Frenchman, Laplace, made great strides in the application of the theory to the motions of celestial bodies. It is true perhaps that in those early days theory predominated and the accuracy of the fit with natural phenomena was none too well established. In the nineteenth century, however, great progress was made in the process of adapting theory to practice in celestial mechanics, and the work is still in continuation to-day. Modifications have been made, such as the relativity theory, which are varied and important, but the foundations still rest on the researches of the men whom I have mentioned and their contemporaries.

I have spoken somewhat hastily about the origin and development of mathematical analysis and I should like now to mention some of the products of this development which affect materially the prosperity of the human race to-day. If you are on a voyage and strike up an acquaintance with the navigating officer of a ship and accompany him to the bridge, he will tell you perhaps that mathematics plays a very small part in the practice of navigation. If you are mathematically inclined you will be surprised at the limited amount of mathematical knowledge and computation which are required for the determination of the position of a ship at sea. A few observations and some elementary computation with the help of tables is all that is necessary. But one should not be deceived. There are few domains of applied mathematics where the operations used in practice have been so tabulated and systematized as they have been in the practice of navigation. Behind the tables of the motions of celestial bodies used by the navigator lies the whole history of the development of the calculus and its applications to celestial mechanics. Without Newton, Lagrange, Laplace, Hill, Poincaré and many others, who developed the theory, and without the Delaunays and Newcombs, who fitted the mathematics of their predecessors to the heavens, the problems of the modern navigator would be unsolved and international commerce as we know it to-day would be impossible. It is well known of course that the art of navigation has mathematics in it, but I think that few persons of the general public realize the distinctly mathematical character of the celestial mechanics upon which the theory of navigation is based. It is perhaps the most fundamentally important and effective single application of mathematics which could be mentioned.

There is another assistant to the navigator which has mathematics in it,

namely, his map. It is well known to mathematicians that the surface of the earth can not be mapped upon a plane in such a way that angles will be preserved and distances on the map be everywhere proportional to corresponding distances on the earth's surface. A map of this kind, if it were possible, would be most desirable and satisfactory. Since it is not possible to make such a map we must be content to approximate to it as closely as possible, or to construct maps for special purposes portraying accurately a part only of the geometrical properties of figures on the surface of the earth in which we are interested. Thus we may ask for a map preserving areas to scale; the battery commander in the field needs a map which preserves angles and indicates distances with the least possible error for a limited portion of the earth's surface; the navigator uses a map which represents loxodromes, or curves of constant direction on the earth's surface, as straight lines. To determine the course of a ship along such a loxodrome one needs only to rule a line on the navigator's map from starting point to destination.

Maps of all these types, and many others, have been constructed. Archimedes knew a fundamental property of one of the area-preserving maps, and Lambert and Bonne constructed others in the latter half of the eighteenth century. The maps of Bonne were used by navigators on the Atlantic for many decades. Curiously enough, the map now used most extensively in navigation is one published by Mercator in 1569. He described accurately its property of representing loxodromes by straight lines, but gave no theoretical explanation. Lagrange in 1779 invented a map which preserved angles and represented meridians and parallels as circles on the plane.

All these are special cases and there are many others. For the general principles applicable in the theory of map-making the mathematician would turn, I think, to a memoir published in Latin by Gauss in 1827 and whose title translated would be "General investigations of curved surfaces." This is a famous old memoir, containing principles useful not only in map-making but in many other domains of applied mathematics. It was the precursor, for example, of the geometrical theories of Riemann, and of Ricci and Levi Civita, and of the relativity theory of to-day. But I have said enough about map-making. Without maps and the mathematical theories of surveying which go with them, the navigation of the present, and many of our modern engineering enterprises, would be impossible.

There is a type of activity of the average university professor of mathematics which I think is fairly described by the term mathematical settlement work. It consists of efforts to answer questions of more or less serious mathematical character proposed by members of the faculty outside of the mathematical department or by members of the community outside of the university. These questions usually have little mathematical interest, but they sometimes have a very considerable significance for the proposers.

Questions concerning amortization of payments are common. A neighbor of mine, now very near the top in a large manufacturing concern, told me gleefully that he made his first favorable impression upon his superiors by solving a mathematical problem of amortizing the costs of sprinkling systems for a flock of factories against savings in insurance premiums. It took him a "week of nights," to use his own words, to find and check by cut and try methods the results he thought he needed, but the net result was an annual saving to his company, after a period of years, of a good many thousands of dollars. Mathe-

matically the problem had no real difficulty, though, as I remember it, a method of approximation was necessary for its solution if tables were not used. I should hate to think that there are many such situations in the business world whose mathematical possibilities go unrecognized.

An efficiency expert called upon me unexpectedly late one Saturday afternoon. He seemed at the same time excited and depressed, and it turned out that he had been trying for several days to construct norm curves for the guidance of salesmen for a certain business house, in accordance with specifications prescribed by its chief executive. He was disturbed in his mind, talked rapidly, and it was impossible to think while he was present. But within a half hour of his departure it became clear, by a mathematical demonstration which was agreeable to me at least, that curves of the kind demanded were impossible. A number of different curves could be constructed, each having some of the properties specified, but there was no single curve possessing all of them. I naturally hastened to the telephone to bring relief of mind to a fellow mathematician in distress. But the effect was far from satisfactory, for what chance has mathematics in the mind of an efficiency expert as opposed to the instructions of a business executive?

From questions which reach us it seems that graphical methods or special tables, often expensive to prepare initially, might in the long run be economical in many situations in the business world. Some years ago one of our students graduated and went into business with his father in the manufacture of boxes. He found that their salesmen were having difficulty in computing costs. The costs depended upon seven variables corresponding to different sorts of materials which might be used. The computations were frequently long and embarrassing in the presence of a customer, and sometimes it was necessary to appeal to the home office. One of the members of our department devised a graphical method which relieved the situation. The cost of computing the tables and drawing the graphs was twelve hundred dollars, but the box manufacturer seemed satisfied, for the average computing time for his salesmen was reduced to two minutes.

Not very long ago a patent attorney came to me from a manufacturer of large storage tanks. He wanted advice in the design of tanks on which the pressure of the contained liquid should be at all depths the same, so that the tank could safely be constructed with a skin of uniform strength and thickness. With the connivance of a physicist the differential equation of the form curve for the side of the tank was set up, but it proved to be of a type which could not be solved in terms of elementary functions. A formula familiar to differential geometers, but beyond the curriculum of the average engineer, furnished an effective graphical method of solution. Designs for such tanks have now been made by engineers and are being patented. The problem is related to the well-known mathematical problem of the determination of the form of a drop and has considerable mathematical interest. If I had pursued the investigation to its finish I should have wanted to inquire carefully into questions of stability, but engineers have doubtless methods of their own for insuring safety in this respect.

I have mentioned these mathematical incidents, not because any one of them is of great importance in itself, but because, if they are as a group typical, they indicate that business and industry are permeated with problems which are not only susceptible of mathematical treatment but whose satisfactory solution requires such treatment. There are

many others which might be mentioned. It amused me the other day to hear from an economist that one of the great mail order houses has mathematical formulas regulating each day the speed of operation of various departments as functions of the weight of the morning mail sacks. There must be many mathematical situations whose mathematical character escapes notice, and not always perhaps on account of the inexperience of executives. I should like to relate to you an experience of my own which shows that sometimes a really intimate acquaintance with a problem may be necessary before its nature can be well appreciated.

In 1918 one of my mathematical friends, Professor Oswald Veblen, of Princeton, was taking a prominent part in the ballistical work at Aberdeen Proving Ground. He wrote urging me to join the group of mathematicians associated with him there, but I refused, because my experience in ballistics was that of the merest dilettante and because I thought I could be of greater service elsewhere. His insistence was so urgent, however, and my confidence in his judgment so great that I finally agreed to his proposal. My surprise, upon becoming acquainted with the problems of his staff, was complete. Before the war the theory of ballistics contained an approximation, valid only for trajectories with low initial elevations, whose application made it possible to integrate the differential equations of a projectile in terms of elementary functions. The theory was satisfactory until long-range guns began to be elevated above twenty degrees, and then it became necessary to revise it completely. The new methods, based on principles altogether different from the old ones, were provided by mathematicians and are ably presented by F. R. Moulton in a recent book on exterior ballistics containing much new and remarkable material which he himself and others have contributed.

The particular problem in which I was with others interested was the computation of differential corrections to the ranges of projectiles due to such causes as variations from normal in the temperature or weight of the powder charge, variations from normal in the weight of the projectile, winds, and variations from normal in the density of the air at various altitudes attained by the projectile, and for very long trajectories the rotation of the earth. The computation and tabulation of these corrections in form convenient for rapid use by the battery commander in the field is a complicated mathematical problem, and is a fundamental problem of range table construction. It is also a very costly and arduous one on account of the large variety of projectiles whose behavior must be studied and tabulated.

When the initial velocity and elevation of a projectile is given the range under normal conditions is theoretically uniquely determined. But if a wind is blowing it may vary widely from the computed value, and the projectile may fail to reach its mark. The velocity w of the wind at various heights is determined as a function of the altitude y by sending up a small balloon and observing its positions at equal intervals of time, and the range of the projectile is a function of the wind-function $w(y)$. I do not wish to enter here into mathematical details farther than is necessary to indicate that the range as a function of the winds is a function of a new type. It is not a function of a single variable, or of several variables, such as one commonly meets in applications of mathematics, but it is a function of another function or, as mathematicians sometimes call it, a function of a line. The computation of the first differential of this function is the computation of the wind correction to the range.

Now the theory of functions of lines is on the farther boundary of the explored mathematical domain of to-day,

and I for one should never have expected it to have an application in ballistics. Its methods were effective, however, for they reduced by three fourths the labor in computing the most numerous corrections in the range tables, and the cost of these improvements in terms of scientific experts was negligible in comparison with savings which would presently have accrued if the war had continued. I may add that the importance of accurate range tables can hardly be over-estimated. An improvement in a range table which might reduce by one the number of shots fired for adjustment from a fourteen-inch gun in order to attain a target, would on each such occasion save one third or more of the average salary of a scientific expert at 1918 rates. I leave you to make further computations if you are interested.

It seems to me that this bit of applied mathematics is interesting in itself and that it illustrates principles upon which I have insisted here before. No one can foresee what portions of the science of mathematics of to-day may have applications in the future.

I have said very little up to the present about the theory of statistics and its ever-widening field of applications in business and industry. Of the mathematics of the actuary I shall have little to say. From the standpoint of the mathematician much of it is elementary, though not by any means all. Its importance seems to me self-evident. There are plenty of instances of pension schemes and insurance enterprises which have failed because of neglect or ignorance of the mathematical principles involved, and the importance of such enterprises to our security and happiness when wisely administered needs no advocation. Without the mathematics of the actuary and the so-called mathematics of finance I believe that such administration would be exceedingly difficult, if not impossible.

There has recently come to my attention an application of the theory of statistics of a different sort which has interested me much and which indicates, it seems to me, a type of industrial question which can be answered satisfactorily by means of statistical theory and perhaps not so answered by any other means. For some time past one of my colleagues, Dr. Walter Bartky, has been associated with a very large manufacturing company as a consulting statistician. The theories with which he is engaged are theories of sampling whose purpose is to provide methods of testing economically and effectively the product of departments or machines which turn out duplicate pieces in large numbers. Shewhart and Fry, of the Bell Telephone Laboratories, and perhaps others also, have studied questions of this and similar character, but all these efforts to apply statistical methods to testing problems are, I think, of comparatively recent date. The technical information which I have comes largely from Dr. Bartky and I am much indebted to him for it.

I can not describe the methods involved in detail, but I can perhaps indicate as an illustration one of the simpler questions which can be satisfactorily answered. Suppose that a department or group of machines is turning out pieces in such large numbers, perhaps hundreds of thousands, that inspection of the entire product is economically impossible. The operation of the department as checked by an inspection department will not be perfect, but will in the long run produce a percentage of defective pieces which can be determined. For manufacturing reasons it is not advisable to approve a product containing more than a certain percentage of defectives. This percentage is called the tolerance percentage and is usually small, from one tenth of one per cent. to five per cent. The pieces come through the process of manufac-

ture in uniformly numerous lots, for each of which a number of defectives, determined by the tolerance percentage, is permissible. The numbers given in advance are then three: (1) the average per cent. of defectives produced by the department in the long run, (2) the number of pieces in each lot, and (3) the maximum number of defectives tolerated in each lot. The statistician must determine from these numbers the size of the sample to be drawn for inspection from each lot, and an acceptance number, as it is called, of defectives for each sample, which will indicate in nine cases out of ten those lots which have more than the tolerance number of defectives. Furthermore, this determination must be made in such a way that the total number of pieces inspected, or what is the same thing, the total inspection costs, shall be a minimum.

The probability formulas involved seem to be simple enough, but the numbers occurring in them are so large that it is quite impractical to compute their values without the use of approximations. The discovery and analysis of these approximations and the careful justification of them constitute the mathematical difficulties of the problem. It is hardly necessary to add that when lots detailed for inspection are determined by a multiple sampling process, or when the piece produced is only one part of a more complicated product, or when the flow through the department is regarded as continuous instead of lumped into lots, the problem may become mathematically much more complicated.

It may be interesting to you to hear an estimate, which is not my own, of the possible financial significance of the application of these methods. The cost of producing a single chart for the guidance of a department of inspection may in some cases be as much as several thousand dollars, and the annual cost of a statistical department may run as high as fifty thousand dollars per year. But the total costs of inspection in the concern of which I am speaking, for problems which might be susceptible to the mathematical theories of sampling processes, may be estimated roughly at three million dollars per year. Of this amount the mathematicians might hope to save one quarter at least and possibly one half. The sampling costs in one department, where methods not yet perfect are in operation, have been reduced, with an actual gain in efficiency, from one hundred and twenty-five thousand to one hundred thousand dollars per year. The total inspection costs which might be amenable to such savings in a larger group of affiliated companies can probably not be calculated with accuracy, but I am told that a conservative guess would be fifteen million dollars per year. These totals are somewhat incomprehensible to an individual mathematician like myself who jingles only silver, and at times only keys, in his pocket. I enjoy the sound of them and should like to hear them talked about frequently, and confirmed perhaps from several sources.

Of the relative effectiveness of mathematical methods as over against surmises in statistical problems I have no doubt whatsoever, and I know of no more appropriate applications of statistical theories than problems of the type which I have just described. If the sums involved are as large as they seem to be I can conceive of no poorer policy than to leave the solution of such problems to foremen of departments, or to the common sense or business judgment of executives who have limited mathematical experience. They are clearly mathematical problems and should be solved by mathematical methods, in so far as mathematical methods can be devised to

apply to them and mathematicians with research interest and experience induced to take an interest in them.

I have so far said very little about the applications of mathematics in engineering and I hesitate much to do so before an audience including many who would be much better qualified to speak upon this subject than myself. But I will try to give you some of the impressions of a pure mathematician in the presence of the mathematics of the engineer.

I find that practicing engineers, and members of engineering faculties, frequently show great reluctance in admitting that mathematics plays an essential rôle in engineering problems, though the books on engineering seem to tell a different story. However much the engineer may prefer to avoid thinking in any except the most intuitive mathematical terms, yet there is after all an irreducible minimum of mathematics in his science, including principles of the calculus and some of a more advanced type, without which he would be very uncomfortable indeed, and which are in fact in some form or other indispensable to him. I was much interested recently to find in print an exposition of the engineer's mistrust of mathematics, in the last chapter of a well-known book on the strength of materials. The sentiments there expressed are not my own, and the comments on mathematics there made will not all stand the test of accuracy, but it seems to me that the attitude of mind exhibited is somewhat like that of other engineers with whom I have conversed about the matter. The keynote of the chapter is the adjuration to use common sense in avoiding mathematics where mathematics is inapplicable, and in avoiding tests where testing conditions do not properly duplicate the conditions under which the results of the tests are to be applied. This is wisdom to which I should heartily subscribe. But in deference to mathematics I should like to add one further principle. It is that common sense should also be scrupulously avoided in places where common sense does not apply. No amount of common sense unaided can predict the motions of the heavenly bodies, or construct a range table, or prescribe the most economical and effective methods of testing under conditions such as I have described above.

That mathematics may sometimes be a guide and not merely a tool in engineering research is well indicated in a very interesting letter which I received recently from Dr. T. C. Fry, of the Bell Telephone Laboratories, and which I will translate in part to you in my own words. If there seem to you to be discrepancies with the facts in my account please attribute them to me and not to him.

Pupin's paper of about 1900 on loading of electrical circuits marks an epoch in the development of telephony. Heaviside had suggested the possible advantages of such loading, but Pupin reduced these crude suggestions to exact form by means of a mathematical investigation, and checked his results experimentally afterward. I may say for myself that one of Pupin's papers of this period, which I happen to have in my library, is an exceedingly interesting application of what mathematicians call a boundary value problem for a differential equation of the second order.

Alternating current theory is in fact the theory of linear differential equations of the second order. Modern developments in this domain are due to Kennelly, Steinmetz, Carson, Bush, Wagner and Gustav Mie. I infer from Dr. Fry's letter that the applications of the theory to more complicated electrical networks lead again to boundary value problems of somewhat the same type as those studied by Pupin.

The transmission of more than one telephone message over a single pair of

wires is accomplished by means of wave filters designed upon purely mathematical developments by Campbell, Carson and Zobel. The enormous economic importance of this application is clear if one remembers that a single pair of long distance wires now carries as many as three telephone conversations and twenty telegraph messages all at the same time.

The story of the first submarine cable across the Atlantic is dramatic. Lord Kelvin, who was plain Mr. Thompson at the time, was the scientist involved. On the basis of reasoning that was at least indirectly mathematical he concluded that the cable should be worked at lower potentials than those which were proposed by the chief engineer of the project. After the cable was finally completed the engineer acted upon his own judgment and the cable was utterly ruined inside a week.

Within the last two years a new epoch in submarine cable telegraphy has begun as a result of the use of the new magnetic material, permalloy. The chief credit must go to permalloy, but it would have cost enormous sums of money to find out the things which Carson and Gilbert deduced mathematically. A pure mathematician might not approve of all the details of the analysis used, but the cables have been laid, and they transmit four times as many words per minute as the best of the old sort.

This is an impressive list of the achievements of mathematics in a single domain, indicating how intimately interwoven that science is with the applications of electrical theories in the industries. I am greatly indebted to Dr. Fry for it. I have omitted with regret the applications of statistical theories which he mentioned in his letter, in some of which he has himself been intimately engaged, because I have already spoken at considerable length upon that subject.

There is one further type of applied mathematics which I should like to mention. The applications of mathematics which I have hitherto cited, and doubtless many others immediately important for the industries of to-day, depend for the most part upon the theory of functions of a single variable. No sharp line of demarcation exists between them and the more advanced theories which I have in mind at this moment, but the latter may be roughly characterized by the fact that they involve functions of several variables instead of a single one. Among them are included the mathematically more intricate portions of the theories of gravitational attraction, thermodynamics, hydrodynamics, elasticity, sound, and electrodynamics with its related theories of light. The whole lot may be fairly described by the single title, the mechanics of continua. It is characteristic of problems in this field that they lead to partial instead of ordinary differential equations, and the mathematical problem which most frequently emerges is that of determining a solution of a partial differential equation which is well defined in a certain region of space, and which is determined uniquely by properties on the boundary of the region prescribed by the physical question whose answer is sought. Examples of problems of this type are the determination of the potential functions for a gravitational field, the determination of temperature variations in a field when temperatures at the boundary are assigned, vibrations of strings and membranes, the determination of potential functions for electrostatic or magnetic fields, and many others. I must admit that these problems have a great fascination for the mathematician, irrespective of their applicability in the industries or in neighboring sciences, and I am willing to make this admission in spite of the fact that the yielding to such fascinations is sometimes implied to be a fault rather than a virtue.

Much work has been done by mathe-

maticians in the domain of boundary value problems, but an enormous amount remains to be learned about them, and the subject will probably never be exhausted. The further development of methods of computation which will make theoretical results of immediate service in the applications is highly to be desired. Until such methods are known we can not hope to convince fully the practitioner of the importance of these theories from his standpoint. That the more advanced mathematical theories have great value in the interpretation of phenomena apart from numerical applications, however, seems to me well illustrated by the avidity with which the physicists have recently seized upon the theory of relativity, and by their restless searching for an adequate mathematical explanation of the phenomena of the quantum theory. One by one mathematical devices for this purpose are invented, tested and discarded, with a rapidity which is bewildering to mathematicians and to the physicists themselves. The situation in the quantum theory has been described as analogous to that of the theory of celestial mechanics just before the time of Newton, and it is said that a super-Newton is required to unravel the difficulties in which the physicists now find themselves involved. It seems to be so, and I know of no more likely way for a mathematician to win great reputation at the present time than by entering into this domain. The only difficulty is that ascent to the pinnacle of fame is likely to be laborious and difficult, tenure of equilibrium there unstable, and descent unceremonious. From failures quite as much as from successes, however, the final solution will doubtless be evolved, and if present indications are to be trusted its character is likely to be mathematical as well as physical.

It is interesting to notice that the mathematical quantum explanations have been for the most part developed in Europe. We have at present in America, and have had in the past, relatively few scientists of prominence devoting themselves to the more advanced domains of applied mathematics. We have had no adequately populated school of applied mathematics from whose membership greater minds might be expected at reasonable intervals to emerge. Comparatively recently agitation has been started for activity in this domain, and a beginning has been made. But the sympathetic support and appreciation of practicing mathematicians and engineers, of the pure mathematicians, and of scientists in other neighboring domains is urgently needed.

In conclusion let me set forth the three hopes which I have desired to further in some small way by the preparation of this paper. I am hoping first that the calculus, which is so important in the immediate applications of mathematics to-day, may be presented earlier and more clearly in our college curricula, and that it may become a familiarly convenient tool and friend to the practicing mathematician, instead of a stumbling block and barrier. In the second place, I am hoping that avenues of communication between the industrial and mathematical worlds, numerous and broad and open, may be constructed, and that traffic in ideas and fluidity of adaptation of such ideas may be freely encouraged between the two. My third hope is that we may have in America a well-populated school of applied mathematics with corresponding activity of interest in the applications of mathematics in all their phases, a school which in personnel and numbers shall be comparable with the dignity of our representatives in the other sciences. Beginnings have been made, but encouragement and appreciation are necessary from all of us, even if results achieved

do not fit perfectly into our individual scientific or practical needs.

I have been speaking for mathematics in response to the request of your chairman, and because it is the only science which I could in any way adequately represent. But it would be a very narrow mind, it seems to me, which believed that mathematics, or any other science, has a uniquely fundamental rôle to play in the interpretation of the universe of phenomena about us. The keynote of our age is cooperation, and for the scientist that means cooperation in the restless and inevitable effort of the human race to transform a life of slavery into one of mastery, as far as may be possible, of the natural forces in which we find ourselves immersed. I shall be satisfied if I have indicated with some degree of clearness the desire of mathematicians, as members of a much larger community of natural scientists, to aid in that transformation.

PUBLIC HEALTH

By Professor RANDLE C. ROSENBERGER

JEFFERSON MEDICAL COLLEGE, PHILADELPHIA

When we become reminiscent and think of the appalling death list attributable to typhoid fever alone, it certainly looks at the present time that many lives may have been saved.

This monster of super Gargantuan proportions with seven (or more) league boots, stepping here and fouling a water supply; again leaving a filthy spot or area for flies to breed; or, for some poor, uneducated people to come in direct contact with and thus spread infection, we believe, and the statistics also prove, that this monster can be held in check.

C. Macfie Campbell in his monograph on delusion and belief says that "man is no longer impotent in the face of devastating forces of disease, but by mastering the nature of these forces and studying his own bodily resources he has erected cunning defenses."

The "mastering the nature of these forces" and "erecting cunning defenses" has been the result of problems solved principally by sanitary engineers.

An engineer is described as being one who carries through an enterprise or artful contrivance.

The artful contrivances must be inferred to mean those that are performed or are characterized by art or skill or both.

Again, an engineer is described as being an efficient manager, so, taking the meaning of the terms we have in the most liberal form an engineer is one who carries through or manages by skill or art, or both, some enterprise or feat.

This enterprise may be one that comprises the selection of a water supply of a town or city; it may mean the disposal of sewage, garbage and other like wastes; it may mean the disposal of, or disposal and recovery of irritating or poisonous dusts and fumes; it may mean the perfection of a model building or factory where workmen or laborers may work in safety; it may be the perfection of an apparatus or equipment for the proper handling of such foods as milk, eggs, gelatin, etc. Besides these projects we may include the methods introduced for the destruction of mosquitoes and for their eradication; insuring the safety and purification of the supply of cows' milk as well as methods for the prevention of disease and death in the various industries.

Thus it is seen that these multiplied engineers comprise a great army tending

in the main towards the prevention of disease and prolongation of life from many angles.

The results attained by engineering feats for public health are numberless and diversified, but particularly outstanding are those brought about where certain diseases have been stamped out and eradicated, in some instances, forever.

In the early days when infectious diseases were thought to be brought about by miasms or humors, where pioneer work was instituted, especially in the purification of water and disposal of sewage, these pioneers for health were indeed great engineers for the cause of humanity.

The work of Virchow in Germany was a most noteworthy example of sanitary engineering, and in our own country the efforts of Osler in preventive medicine, especially in the infectious diseases, were inspirational in what has been established along this line.

Naturally, one of the greatest and most widespread beneficent engineering projects is the establishment and maintaining of a pure, wholesome, safe water supply.

This, one must bear in mind, takes into consideration the actual or absolute source, and while directing it into its proper channels for household consumption, it must remain unpolluted either from an animal or human source.

It must also be borne in mind that a reserve supply of this water must be housed or stored in reservoirs, which reservoirs must be constantly inspected and really guarded to prevent any contamination or pollution of this food stuff.

This, in my mind, is a great and wonderful engineering feat, to harness a water source and shed miles and miles away from a town or city, and prevent its contamination up to the actual consumption of the product!

On the other hand, the purification of a polluted or contaminated water by mechanical and chemical means, though it is a measure of making the water safe from a bacteriological standpoint, is not nearly such a wonderful feat as the actual selection and maintaining of a pure and undefiled water for all household purposes.

Together with this problem may be linked the swimming pool, which to-day, thanks to sanitary engineering devices, keeps the water as clean as the water we drink.

Coincident with the purification of water and equally important to our health is the proper and safe disposal of sewage and wastes.

The habit of dumping garbage and sewage into the ocean or inland lakes is a makeshift and should not be tolerated in any large community.

Nuisances no doubt result from such practices and diseases may be disseminated.

At the present time any first-class municipality should erect and maintain proper disposal plants for sewage and wastes other than sewage. The installation of incinerators or destructors for rubbish is the surest method of disposal.

The Beccari system of garbage disposal is a most ingenious and desirable method of ridding municipalities of this offal. I think it is also a most wonderful achievement in the eradication and prevention of hookworm disease. Naturally, this has been primarily a problem of education, but it has as well been an engineering problem, in the disposal of excreta and the prevention of soil pollution.

Thousands upon thousands of lives have been saved and others bettered by the methods laid down by the International Health Board in the management of the hookworm problem throughout the world.

In industries, where arise quantities of dusts of many metals, where vapors and gases in the manufacture of manifold products are generated, an ingenious process for the removal of these dusts and gases and their recovery from the working atmosphere is abundantly and successfully accomplished by means of the Cottrell electrostatic process.

The wearing of masks, goggles and helmets are a decided and added protective measure against these poisonous and offensive suspended materials, together with exhaust devices.

From many industries the air is polluted by smoke and particles of carbon, and at the present time devices have been perfected for the recovery and disposal of these gases and solid particles which otherwise would be deleterious to health.

In these days of subways and tunnels great engineering problems take into consideration the safety of travel, by ridding the atmosphere of vitiated and poisonous gases and installation of devices for proper ventilation. I do not think it at all amiss if mention is made of the efforts of municipalities in the adoption of devices trying to solve the question of safety in the momentous question of traffic problems.

Apart from the dust and gas removing appliances, one of the greatest engineering procedures in industrial hygiene and medicine is the physical examination of prospective workers and the periodic examination of those accepted for such work. Were it not for these overhaulings many grave insidious forms of poisoning would take place; or many fatalities would occur in individuals engaged in the construction of foundations for bridges or tunnels, if the workers were not properly selected.

Even in time of peace this method of selection of healthy and suitable men is going on to keep our quota in the army and navy in fit condition. Apart from this phase, the suggestion for periodic health examinations of individuals in all walks of life is an instance of conservative engineering.

Again, regarding the industrial worker, think what the engineer of health has done in supplying the industrial worker with a workshop or room, with the so-called sunlight walls and up-to-date ventilating systems! Natural sunlight, right at his loom, his desk, his grindstone, his furnace or his workbench. No dim lights, no unguarded stairways, no unguarded belts or saws!

In their stead we have proper equipment, proper tools, efficient safety devices for all sorts of machinery; rest periods and real rest rooms for relieving tension of all kinds.

Another problem in industries as well as in ordinary walks of life is the one pertaining to tuberculosis. This was another question that interested Osler very much, and he was among the first to put forward plans and organize for the study and prevention of this disease.

Trudeau in Saranac was, as we know, a pioneer as well as engineer in the outdoor fresh-air treatment for this disease, and from that modest but earnest effort there has arisen the numberless sanatoria for the study and treatment of this plague.

From the progress noted in the institutional care of these cases we know that we are getting the better of the disease.

To-day we have also the pertinent question of engineering a project where the children of tuberculous parents may be segregated from the parents where ignorance regarding dissemination exists and the environment is not suitable for proper development.

In a number of instances where tuberculosis was said to have been brought about by dusty occupations, it was found by surveys made of the industries, as

well as the homes of the workers, that the home life and environments were far more to blame than the industry itself.

We are all familiar with the beneficent action of the ultra-violet rays as a bactericidal agent, and to-day the administration of sunlight both natural and artificial to patients with tuberculous diseases is followed by wonderful recuperative effects in these cases.

Is it not also a wonderful procedure at present, where the patient is treated in a room which is lighted by panes of glass which filter out the red rays, and thus the beneficial rays play upon the diseased body for any length of time desired!

Passing from the industrial workers our next consideration is of one of the most widely used foods and one that we can not at present curtail. I refer to milk; its production; its handling; its present treatment; its preservation, distribution and consumption. No one will gainsay that, next to mother's milk, it is the most important food for the infant and growing child.

To-day we are making wonderful studies in the adoption of the so-called accredited herd system in the dairy industry and until this is generally, or I might say, nationally adopted, our attempts at proper pasteurization must be upheld to the letter.

The farmer is in some cases the stumbling block in testing his cattle against the disease, tuberculosis; but he must be taught, the public must be taught the danger from one diseased animal (which looks particularly healthy) in a herd of five or six cattle, or in a herd of fifty or more.

The tuberculin test is the best method we have at present in the detection of tuberculous disease in cattle, and where no naked eye lesion of the disease is apparent in a reacting animal, an unenlightened person may condemn the test.

It is true we do have such reactions occurring in some animals, but microscopic studies reveal the disease in most cases.

If we can not at present obtain our milk supply from animals free of disease, then our next best procedure is the proper pasteurization of the product. That is, the milk must be held at 60° C. for at least thirty to thirty-five minutes, although the laity does complain that the cream line is not as deep in some as in another dealer's milk.

The handling of milk to-day from the many receiving stations in the country districts in the thermos-bottle-like cars and the pumping of the milk into these cars does away with a great deal of dirt and other extraneous materials which reached the product in the old methods of handling.

After an inspection of many up-to-date receiving stations and pasteurizing plants, it is my opinion that from the outlay of money for equipment of the buildings, with up-to-date machinery for the pasteurizing and bottling and the distribution of milk, these dealers are doing their utmost in conforming to the rules laid down and the suggestions made by local as well as state boards of health for the proper pasteurization and measures for the proper distribution of a safe milk for all purposes.

The same words of commendation could be made regarding the making of milk products, such as the various brands of dried milk upon the market. These are engineering feats pure and simple and all done for the maintenance and preservation of health.

The examination of those engaged in the dairy business, as to their cleanliness, their present health, their previous health and the possibility of a carrier, as of the typhoid bacillus, is another procedure in the prevention of the spread of infections.

The addition of the mechanical milker to the dairy is another step in the hy-

giene of the dairy, but care must be exercised that it be cleaned properly and receive attention such as any other mechanical device.

Other foodstuffs might be mentioned and one, I might dwell upon for a moment, is gelatin.

I remember, years ago, when examining the finished product that millions of colonies of various bacteria and moulds would be encountered. To-day, through proper handling of the product, the disposal of dusts and the refrigeration method of cutting the ribbons of gelatin, a sterile product is produced quite regularly without the addition of any acids or preservatives.

Passing from foodstuffs, we will next consider engineering in medicine toward the prevention of diseases brought about by insect dissemination.

We need not again repeat, at this time, the names of the heroes who gave their lives in the interest of science, to prove upon themselves or working directly with the diseases, that dissemination takes place by these agents.

The most wonderful discovery, in my mind, was in the yellow fever problem, where it was proved, after thousands of lives had been sacrificed, that a certain mosquito must bite a person before he contracted the disease.

The final steps in the completion of the Panama Canal could not have occurred, except for the epochal study in yellow fever and its dissemination.

Of course the dissemination of malaria by other mosquitoes was known, but the disease was not so fatal as yellow fever.

The knowledge gained by tracing the dissemination of diseases by insects naturally led to the destruction and eradication of these pests and the culmination of many engineering feats apart from the Panama Canal were accomplished.

The exact knowledge regarding the distribution of the tsetse fly is another point which from the standpoint of cattle raising with its many side issues, and the propagation of disease in man, speaks very well for the sanitary engineers in keeping these areas free from these flies.

The method of treating the surface of ditches, pools and streams with crude oil and various mixtures of crude oil for the suffocation and poisoning of larvae of insects was indeed a wonderful engineering project. Imagine what a feat it is, where a dust containing one part of arsenite of copper per hundred, applied to breeding places of anopheles or malaria-bearing mosquitoes, acts specifically upon the larvae of these mosquitoes but does not affect the larvae of other varieties or the larvae of flies.

The method of distributing poison from an aeroplane was ingenuously novel, and according to reports very successful against the destruction of these disease-disseminating insects, as well as others.

Going hand in hand with the dissemination by insects is the possibility of rodents spreading infection, either by their bite or by harboring insects and other parasites. This has led to the building of ratproof buildings, such as storage houses, which has kept the propagation of rats down considerably.

Now, regarding one big phase of disease prevention, though it is in the consideration of little things—children—the methods to-day that have been brought forward in the curing, as well as in the prevention of rickets by ultra-violet rays and increasing the potency of cod liver oil is an epochal achievement. The organization and establishment of various societies for the prevention of tuberculosis and the prevention of cardiac disease stand out as two very important links in the chain of engineering for health and prolongation of life.

While compulsory vaccination against smallpox absolutely protects us against

epidemics of this disease and the antitoxin of diphtheria and antitoxin of tetanus prevent and cure these diseases; and the administration of various convalescent sera against communicable diseases, while not specifically recognized nor spoken of as engineering problems yet, when analyzed, are just as great engineering feats and accomplishments in the prevention of diseases as the purification of the water supply or the proper disposal of infectious wastes or poisonous dusts.

Mention alone can be made of the work that is being done by our fellow scientists, the chemists. I say chemists broadly, because by specializing any branch of the science we certainly perchance miss one or two of them.

These busy bees of our life delve into every phase and question of our living; they dissect, inspect and recommend the things we eat, the things we wear and peer into the most important aspects of light and heat.

Chemical engineers are turning out products every day, some of which never existed before, and determine means of water purification for the sanitary engineer; and, for the civil engineer, testing water-purifying substances to prevent corrosion of boilers and pipes and thus bring up a question of life saving and conservation.

We are also indebted to them for the perfections of the X-ray machine, for medicines and appliances which alleviate suffering and make human lives happier.

One of the many things which is being worked upon now is an apparatus or appliance to enable the deaf to hear and the dumb to speak.

In summing up the results of the various agencies at work in the prevention of disease, in protecting the workmen and in teaching the methods of proper living to our growing population, it is manifest that the corps of engineers is a large one, the sanitary engineer, the chemist and the physician being especially prominent in playing a part in the health of the world to-day.

The public must be educated and this can not be done by posters with grotesque, fanciful and sometimes childish or silly legends or slogans. The education must begin with the child, at home as well as at school, with practical demonstrations.

In many instances parents are taught by their children who have gotten lessons in cleanliness, health and well-being from their teachers at school.

A word of praise, which I think is well deserved, should be given to the school teacher, and the social worker as well, who many times have had to act as parent and teacher to many children who lack this very important link in the developmental years of their lives.

PSYCHOLOGY

By Dr. J. McKEEN CATTELL

FORMERLY PROFESSOR OF PSYCHOLOGY IN THE UNIVERSITY OF PENNSYLVANIA AND COLUMBIA UNIVERSITY; CHAIRMAN OF THE DIRECTORS OF THE PSYCHOLOGICAL CORPORATION

The alphabetical order of the sciences in this discussion places astronomy first and psychology last. This is also the historical order of their development. The facts of astronomy, based on observation and measurement, formed an organized body of knowledge at the earliest stages of civilization. The calendar and the measurement of time, the use of observations of the heavenly bodies in surveying and navigation, not to speak of soothsaying and astrology,

were among the earliest applications of science. Psychology has become a science only in the course of the last fifty years. I have special interest in the circumstance that the first professorship of psychology was established at the University of Pennsylvania in this city thirty-eight years ago. Applied psychology and psychological engineering are in the main problems of the future.

While psychology is the most recent of the sciences on this program, its subject-matter has long engaged both philosophical speculation and the interest of the every-day man. As we now see it, or at least as I see it, psychology is the science of how individuals think and act. This was the principal concern of primitive man, as indeed it is of the lower animals. Each is interested before all else in his own mental life, in his own behavior and the behavior of others. Satisfaction of desires and wants, aversion to pain and danger, exist at the outset of life. The control of behavior also begins early in the animal series and in the new-born individual. Young animals learn by experience to adjust their movements to satisfy their needs, and with the same object they seek to influence the behavior of others.

When such is so clearly the case, it may seem at first sight surprising that the sciences, both curious and useful, of matter and energy should have had an earlier origin and a more systematic development than the biological sciences, while psychology is only now taking its place among the descriptive sciences and has witnessed but its first beginnings as an applied science. The explanation is in part the difference in complexity and stability of the objects of the several sciences. Matter is plastic to experiment and measurement; minds and behavior elude experimental and quantitative methods. The known performance of the solar and stellar systems since the beginning of astronomy is less complicated than the play of a child for a day.

Another reason for the later development of psychology is that it is easier to satisfy minds and to control behavior by altering the environment than by altering individuals. The savage could shoot an arrow from a bow or move a stone with a lever more readily than he could strengthen his own right arm. He could obtain food better by planting corn than by developing his skill as a hunter. And so it is to-day. By increasing economic production and improving the distribution of wealth, we can do more for the welfare of people than by trying to teach them to be virtuous and wise.

Engineering has a certain analogy to psychology in its early use and its late development into a science and a profession. As psychology may be traced back beyond the first use of language as a means of communication, so engineering is as early as the first use of tools. Engineering works of great magnitude were constructed by the Egyptians and the Romans. But in the modern period for six hundred years theology, law and medicine were the schools of the university. The first schools of engineering were established only a hundred years ago. In this short period engineering has become the profession that is most useful and most securely based on science.

A painting in the library of the Engineering Society's Building in New York bears the inscription: "Engineering—the art of organizing and directing men and of controlling the forces and materials of nature for the benefit of the human race." According to this definition, chosen by engineers, the relations between engineering and psychology are close. The selection, training and directing of men are problems of applied psychology; it is also for psychology to determine what does in fact benefit the human race. In using the forces and materials of material nature engineering has become an exact science; in its relation with human nature engineering

works by the rule of thumb and will continue to do so until it can use an exact science of psychology.

On the one hand, engineering is dependent on psychology; on the other hand, the objects of applied psychology, namely, the control of the behavior of individuals, have been advanced by engineering, invention and industry to an extent incomparably greater than by anything that psychology has been able to accomplish. The applications of science, by quadrupling the wealth that each can produce and by doubling the average length of life, have completely altered our civilization and the way that each of us reacts to it.

The economy of labor and of life which science and invention have wrought has abolished slavery and serfdom. It has made unnecessary productive labor by children and has made possible their universal education. The wealth of society is now sufficient to support adequately every child, to give it the education that opens the gateway to the career for which it is fit, to provide equality of opportunity and a true social democracy. Applied science, based in large measure on scientific research whose utility was not at the time obvious, has been the cause of the political and social institutions that we have and of the lives that we lead.

It appears that engineering and the applications of science have done more to control our behavior than efforts made with this object directly in view, such as those of the churches, the schools, the courts and the state. It may be argued plausibly that the ten commandments would have been broken no oftener, that the precepts of the sermon on the mount would have been followed no less rarely, if the churches had never existed. It may be that it is as futile to herd children in pens to teach them their R's as it would be to use similar methods to teach them to walk and to talk. It is quite possible that there would be no more crime in the world if courts and prisons had never been invented.

These partial failures to alter human nature by direct appeals to consciousness are quoted to emphasize the thesis that applied psychology is concerned with the total relation of the individual to the environment. We can try to alter the individual; but we can accomplish more by altering the physical world in which he lives, perhaps most of all by altering the relation of an individual to his surroundings. As modern medicine has made more progress in the diagnosis of disease than in its cure, so psychology can determine the intelligence of a child, a soldier or a congressman more readily than it can increase it. In like manner as medicine and public hygiene can do more for the health of people by providing surroundings that are sanitary than by curing diseases that have been contracted, so psychology can do more by placing individuals in surroundings where they will act in the way that is wanted, than by attempting to change individuals so that they will act in a more desirable way.

The control of thoughts and behavior has been undertaken by the churches, the schools, the laws and the rest in order to accomplish definite results that are regarded as desirable, but they have largely failed because it is difficult to change human nature. Individuals at birth have definite constitutions, and will react to their surroundings in accordance with them. What we can do is to place them in situations where they will behave as nearly as their constitutions permit in the way that we want. By changing the surroundings we control behavior most effectively. This is what engineering and applied science have done, but they have advanced without special reference to the kind of mental life and behavior that will follow.

What we need is a science that will coordinate all efforts to alter human nature or to control conduct with the effects of all changes in the environment that alter our behavior or increase welfare. This is the business of psychology; that so little has been so far accomplished does not relieve us of responsibility for the future.

Nearly all psychologists have been teachers, and those engaged in research have nearly all been university professors. It is consequently natural that the first and most extensive applications of psychology have been in education. These have covered a large range of teaching and learning, but have been most exact and useful in selecting children for the work that they can do to best advantage. Probably more than five million tests were made this year in the schools. These tests have great advantages over the usual examinations in that they put measurement in place of opinion and aim to determine what a student can do rather than what he has already learned.

The most extensive use of psychological tests in the United States outside the schools was in the army where some 1,800,000 recruits were examined. Although the tests used were not adjusted to determine who would make the best soldiers, they proved useful in selecting objectively those at the upper end of the curve of distribution who were officer material, those at the lower end who were unfit for any kind of service. Most army officers were converted to the utility of the tests, which is certainly strong evidence in their favor.

The proved usefulness of psychological tests in schools and in the army might be expected to lead to their general use in industry, but this is not yet the situation. In Germany tests are used in the selection of apprentices for a number of trades; in Paris taxicab drivers are required to pass an examination by the municipality; in the United States tests are given by a number of corporations. The intelligence tests of the school and army type are especially applicable to clerical workers. I have asked a number of people of competence in business and affairs how much they think production would be increased if each individual from the moron to the genius were given the work that he could do best, were trained in the best way to do it, and the conditions were made such that it could be done to best advantage. The estimates vary from ten to a thousand per cent., which represents a large range of ignorance, say the difference between an increase of the wealth produced by the nation of from ten to a thousand billion dollars a year. Surely it would be worthwhile to determine which of these estimates, if any, is correct and then to adopt the measures necessary to produce the additional wealth, with a proportional increase in contentment and happiness.

Psychological experiments have been carried forward in many directions which directly concern engineering and industry, and in turn engineering and industry have developed methods which contribute to psychology, such as the Taylor system, employment management and industrial engineering. Among innumerable problems that psychology, engineering and industry have in common are the desirable hours of labor; the most efficient movements; interest, enthusiasm and imitation; all conditions favorable or unfavorable to work or other forms of activity, including ventilation, heating and lighting; food, alcohol, coffee and tobacco; rest, play and sleep; posture and strain in employments; conditions of fatigue and safety. An Institute of Applied Psychology in England and a Psychological Corporation in the United States have been established to forward research in psychology and its applications. Our organization

has the cooperation of practically all American psychologists with branches and stations in forty-two states. We can thus look for the rapid development of the useful applications of psychology and its closer coordination with engineering and industry.

As psychology and engineering are closely interwoven, so it seems to me are the useful sciences and the sciences called in this program "pure." There is a clear distinction between the applications of knowledge that we have and the acquirement of new knowledge, between the physician who uses known remedies to alleviate disease and the pathologist who advances knowledge of causes and remedies, between the builder of bridges and the engineer who makes new designs. As there must be division of labor between the psychologist and the engineer, so there must be among mathematicians, physicists and psychologists who on the one side seek to advance science without regard to its applications and engineers who on the other side find new ways of applying knowledge. But the methods are the same and the men are sometimes the same.

Kelvin and Pasteur are notable examples. The former was a great mathematical physicist and at the same time made inventions and engaged in the practice of electrical engineering. Pasteur founded the science of bacteriology in direct work on practical applications—the fermentation of beer and wine, the diseases of silkworms, chicken cholera, anthrax, rabies. In like manner Lister discovered antiseptic surgery, and the great German pathologists, Koch, Behring, Ehrlich and the rest, made their contributions at once to science and to human welfare. As Pasteur remarked: "There is no greater charm for the investigator than to make new discoveries, but his pleasure is heightened when he sees that they have a direct application to human life."

In the short interval at my disposal it has seemed better to discuss some general relations between psychology and engineering rather than to undertake to describe specific cases of the applications of research in psychology to engineering practice. A review of psychology in industry by Dr. M. S. Viteles, of this city, printed in the *Psychological Bulletin* for November, quotes 360 recent publications. A critical summary of these or a detailed review of almost any one of them would take us beyond the limits of the present discussion. What it seems most worthwhile to emphasize is the close relation and the mutual interdependence of psychology and engineering. The body of knowledge is a whole like the human body. Aristotle said long ago that a hand apart from the rest of the body is no longer a hand. So each science exists in large measure in relation to others; psychology and engineering are members one of another.

WHAT TRANSPIRES IN THE KINGDOM OF RESEARCH

By T. SWANN HARDING
BELTSVILLE, MARYLAND

It would be curious to know just how the intelligent layman regards the minutiae of research, how he thinks that the investigator puts in his time. To the investigator himself such laymen appear to regard research as an esoteric province of flaming magic wherein ordinary men divest themselves of monotony and routine, slip on genius like a smock, then discover, enlighten and synthesize higher civilization. Yet the investigator very often feels like some inept animal roaming a strange and forbidden environment, condemned to entirely too much routine and proceeding, not very rapidly, nowhither. He does not, customarily, sense the glamor which induces the layman to declare so glibly that "research must be very interesting."

Just what is research, anyway? Precisely how do these bewildered primates carry on in their sacred precincts? There is much plausible reason for ignorance on the part of the intelligent layman because no one seems yet to have thought of the very simple expedient of tracing out for him the pursuit of "truth" in a specific instance. This exposition should be both diverting and enlightening to intelligent people who often wonder what on earth investigators actually do in their laboratories, besides smoke cigarettes, that is. The writer will therefore endeavor to give in common or garden language an authentic account of one investigator's travail as he sought to solve a problem. His slight triumphs, his frequent and painful rebuffs seem not devoid of interest to the gentry and intelligentsia. The writer has intimate knowledge of the work outlined herewith.

Since all present-day research problems are of necessity small corners and fragments of much larger problems, a slight introduction will be necessary for the understandable presentation of this investigator's actual work. Since this introduction will deal with a phase of nutrition chemistry which is too often inaccurately presented to the public, but which is interesting and informative, and since its presentation will clearly illustrate how an investigator finds and attacks a problem, this preliminary seems justifiable.

As Fischer discovered, the proteins we eat do not enter as such into our living tissues. In fact proteins can not normally penetrate the adult intestinal wall. They do permeate it in early infancy, for the very first milk secreted by a mother, the colostrum, containing valuable substances protective against infant diseases, presents these substances, or "antibodies," in a protein named "globulin." Globulin has to penetrate the intestinal wall in order to do its protective work. But when a protein gets through the intestinal wall of an adult it simply starts trouble; it is toxic and gives rise to symptoms of poisoning each time this leakage occurs.

Thus some persons can not eat eggs without subsequent illness, due to the fact that their intestinal walls are permeable to egg protein, which, entering their blood stream as such, causes illness. This phenomenon is called "allergy" and it is also responsible for such diseases as asthma and hay fever when the protein permeates the respiratory tract.

Proteins are, therefore, broken down in digestion by enzymes like pepsin, and

the proteins of the tissue are rebuilt from these simpler compounds, somewhere and in some as yet unexplained fashion. In fact an animal is very particular about the character of its tissues and of its secretions—milk, for instance. The constitution of the proteins in an animal's tissue differs from animal to animal, from organ to organ. Indeed, there is constantly accumulating evidence that the chemistry of bodily tissues differs from individual to individual. Biological tests lead us to think that the structural proteins of each species of cell have highly individualized peculiarities.

It is highly probable, then—for there is also room for a wide variety of microscopical variations, too, that the proteins of no two humans ever have precisely the same composition. It is not pure speculation either to extend this diversity to such things as brain and nerve tissue, an elaboration which may account for many personal idiosyncrasies, for fixed ideas, beliefs, prejudices and relative immunities to reasoning.

How is such infinite diversity produced? Proteins are made up of smaller units called "amino acids." These are the "building stones" of all body tissue. There are about twenty of them. Ingested proteins are broken down into amino acids during digestion; as such they permeate the intestinal walls into the blood stream. Then, as this red medium, which is to us precisely what sea water is to lower living organisms, bathes our living cells, the cells, with astounding selective accuracy, extract from it precisely the particular amino acids they need to rebuild the tissue in their immediate vicinity. For cells are simply chemical compounds endowed with the capability of reproducing themselves.

Tissue proteins are, then, very complex chains of amino acids hooked together. As Leathes, the physiologist, recently pointed out in the *Lancet* (August 7, 1926) if you allow for a chain of approximately fifty links (not a tremendous sized protein molecule at all—in fact, one of modest proportions) and if you assume the existence of twenty amino acids, each one capable of appearing at any point in the chain, and of being repeated at any other interval therein, you soon begin to deal in possibilities of variation into enormous figures. Suppose one kind of amino acid recurred ten times in the chain, four recurred four times, and ten recurred twice. You get 10^{48} possibilities of permutation. The span of the universe is three hundred thousand light years. This figure, even expressed in Ångström units, is less than 10^{48}. In short, the possibilities for variation in the protein molecule of quite ordinary complexity almost approach infinity.

In spite of what may be found in the press it is an actual fact that the exact function of most of the individual amino acids is to-day unknown. We can not tell how most of them limit the organism by their absence from our food. One of them, glycocoll, can be synthesized by the human body, for casein, which lacks glycocoll altogether, and yet proves to be a complete protein for nutrition. Perhaps other amino acids, like alanine, can also be synthesized by us. We do not know, so ignorant are we of our own chemical reactions.

We do know something definite about the function of five amino acids, namely —tryptophane, lysin, histidine, arginine and cystine.

Zein, the protein of corn, lacks both tryptophane and lysin. Willcock and Hopkins found that animals died in a torpor when zein was the only protein fed them. The addition of pure tryptophane to zein enabled the animals to live (*i.e.*, established maintenance) and the addition of lysin enabled them to grow. Adding tryosine, another amino acid, had no effect whatever. Hence trypto-

phane is absolutely essential to life, lysin is essential to growth and tryosine appears to be quite dispensable.

Osborne and Mendel, excellent but too little known investigators, assuming that gliadin (the protein of wheat and rye) contained a negligible amount of lysin (.16 per cent.) concluded that lysin was not needed for maintenance because experimental animals lived on gliadin. But their results were later invalidated by an analysis which showed 1.21 per cent. lysin in gliadin, sufficient for maintenance, anyway. It is interesting also to know that they were, at this time, feeding a "protein free" milk which was later discovered actually to contain one half the maintenance requirement of amino acids for young animals. This all indicates the pitfalls of physiological research. Nevertheless, it is established that lysin is necessary for growth.

Ackroyd and Hopkins, as well as Geiling, all excellent workers of high standing, found that histidine was necessary for growth but declared that arginine could be used interchangeably in its place. Then Rose and Cox, and also Stewart, again excellent workers of high standing, declared that arginine and histidine are certainly not interchangeable, but that histidine itself is absolutely necessary to growth because it functions as a precursor of purines without which animal chemistry is inhibited. Here the layman may be inclined to sniff. But further confirmation has recently been added to the assertions of the last workers mentioned and they seem, just now, predominant.

Cystine was, until Mueller's discovery of another, the only amino acid containing sulfur. It remains the only sulfur amino acid active metabolically (*i.e.*, which enters into the building up of body tissues). It is needed in very small amount, if at all, for maintenance; but it is absolutely essential to growth. Cystine occurs especially in the hair and nails. It is also essential to milk production.

This summarizes all that is really known about the specific usefulness of the amino acids. We need variety as well as quantity in amino acids. A lack of any one of them from the food may become a limiting factor in the biological usefulness of a protein. However, in the customary mixed diet, the proteins admirably supplement each other and thus offset their individual deficiencies in essential amino acids.

We turn now to milk production since the specific problem lies in this field. Here cystine is essential. Milk proteins are of course also built up of amino acids which the cells of the mammary gland unerringly take out of the blood as it perfuses them. Hence if we are really to know the true value of various feeds for dairy animals we must somehow trace these amino acids from the feed, into the blood, thence to the mammary gland and into the milk.

The amino acids constituting various cereal proteins—such as gliadin and zein—are well known. It has also been demonstrated that amino acids occur in blood. Abel at Hopkins got them directly out of the blood of living animals in what he called a vividiffusion experiment. Abderhalden, after hearing of Abel's work, quickly repeated the experiment in Europe on an enormous scale and with changed technique, but the credit is Abel's. We also know the amino acids composing milk casein and albumin. Tryptophane and cystine are prominent among them. Hence feeds deficient in these two amino acids will obviously limit milk production.

This narrows the subject by picking the problem to pieces. There has also been developed an accurate method for estimating the exact amount of one of the amino acids in the blood, namely, tryptophane. Finally, the cow being a docile and well-mannered animal, it is

easily possible to stick small metal tubes simultaneously into her jugular and her mammary veins and to take from these veins exactly synchronous samples of a quart or so of blood. The animal withstands such seemingly drastic treatment without deleterious consequence save a momentary loss of temper. An examination of these two blood samples, of which the jugular is essentially arterial in make-up, demonstrates that arterial blood contains decidedly more tryptophane than exhausted blood on the way back to the heart through the mammary vein. Caught on its return journey after perfusing that gland, its relative deficiency in tryptophane betrays the fact that the mammary gland extracts this amino acid from the blood in order to build up milk proteins. In technical language we say that the amino acids of the blood are the precursors of milk proteins.

That done it becomes obvious that another amino acid should be traced. Cystine was selected, because of its importance in the constitution of milk proteins, and this at last brings us—by so devious and long a road—to the point where an investigator could select an original problem for research. How, then, did he proceed here?

The first question was, of course, can cystine be estimated in blood? Is there a method to determine it quantitatively? He went to the literature. Some forty articles in English, French, German, Spanish and Italian shrieked to assure him that of course cystine can be determined. But, as usual, closer examination raised a doubt as to whether it ever had been determined correctly at all. So many inaccurate articles are published that this disappointment is an every-day inevitability. Prestige gravitated him in favor of a reliable investigator, and an Otto Folin colorimetric method seemed most promising. If a certain reagent perfected by Folin be added to a solution of cystine a blue color is developed which is exactly proportional in intensity to the amount of cystine present. Moreover, it should determine accurately less than a milligram and there are a thousand milligrams in a gram and about thirty grams in an ounce. An instrument called a colorimeter enables the investigator to measure color intensities with extreme accuracy.

But is all the color always due to cystine? May not other substances—glucose, uric acid, creatinine or insulin produce such a color? These must be tried and negative results secured. Then do the reagents themselves in "blank" give a blue color? Yes. Then they must be recrystallized and purified until the blank is colorless. Is the blue color now actually proportional to the amount of cystine present and if so what is the actual range of delicacy in the method? These things must all be tried out experimentally with solutions of pure cystine regardless of what appears in the literature, because so chaotic is the literature and so uncertain in value are many printed articles that the careful investigator can only dare proceed after verifying personally every slightest detail. This is most unfortunate but true. So much ill-done work appears in the very best journals. A detour must also be taken into other methods of determination to be sure that they are as fruitless as they seem to be. This involves reading and digesting thirty more articles.

But after some months the investigator is ready to attempt the determination of cystine in blood. But blood is full of corpuscles and soluble proteins and these must be got rid of before analysis can proceed. How shall they be precipitated? One hundred articles now howl at him in five languages to tell him which procedure is best. He must wade through these, meantime trying to keep

his critical faculty awake. He finds at last no entirely conclusive evidence anywhere that any method for ridding blood of its proteins can be absolutely guaranteed not to take along always a small amount of the amino acids there in solution. Total amino acid determinations mean little, for 25 per cent. of one of the twenty might be lost without ever showing up in a total amino acid determination. Yet that entire 25 per cent. loss might, for all he knows, be cystine.

Then how would ultrafiltration do? That means passage through a collodion (new-skin) membrane under pressure, which gives what is said to be a reliable filtrate for analysis. Forty polyglot articles again assure him of all sorts of possibilities here and he wanders through the maze experimentally a few weeks.

Thus we see him reading and seeking by laboratory procedure. And in a few months he has a method of ridding blood of its proteins which he is reasonably sure does not decrease its content of cystine. He adds pure cystine to blood before ridding it of protein and finds the added cystine all there intact afterwards. That is reassuring, but there is a doubt saying he may have changed the blood reaction in adding the cystine and thus have set up an abnormal condition. He hopes not and passes on.

He makes his first analysis and it is simply astounding. If he can believe it and all this blue color be due to cystine then one third of all the amino acid in the blood is cystine. This is simply absurd. Then has he to do with cystine altogether? Or at all? This leads to a new and more frantic search of the literature—a hundred devious articles in Babel again. The search is for the most likely organic compound to be in blood and to cause that color. Finally a dipeptide (*i.e.*, compound of two amino acids), called glutathione and composed of cystine joined to glutamic acid, seems most likely. Glutathione was discovered, though, by Sir F. Gowland Hopkins, discoverer of the first amino acid, the light of Cambridge University, one of the leading physiological chemists on earth and decidedly a baronet. And the baronet specifically denies that glutathione occurs in blood!

This is a terrific blow. For prestige absolutely blocks the path. In literature the unknown is published, but he is published only if he is able to impress the editor tremendously. In fact, the unknown must be better than the well-known writer is at best in order to distract the editor's sympathetic attention from even the mediocre and uninspired work of the established writer. So also in science. Established investigators with honors have now as always a prestige which enables them both to gain print and to command respect more readily than mere unknowns. An interesting literature might be cited to prove this, but Murray's "Science and Scientists of the Nineteenth Century" is enough.

Therefore our unknown investigator had to stop and elaborately establish his contention with extreme care. He had to render himself thoroughly familiar with the glutathione literature. He had to match his rudimentary technique against that of experts in this line in order to learn to prepare glutathione. Qualitative tests, three of them, at once demonstrated the baronet's error and supplied valid reason for such a mistake. But in controverting so notable a man only the actual crystallization and identification of glutathione could possibly be admitted as sufficient evidence for publication. So went a year.

At the end of this time of travail the investigator had his theory proven. Not only was glutathione certainly in blood, but it was also apparent that this dipeptide, as such, suddenly left the blood stream to the extent of 40 per cent. dur-

ing one swift passage through the mammary gland. How lightning quick this transference must be we know when we remember that glutathione occurs only in the corpuscles and must transfuse from them into the blood plasma before the mammary cells can grasp it to build into milk proteins. Moreover, the fact that a dipeptide was actually so used as such and without being broken down into its two constituents (the amino acids) afforded the first instance of such a biological utilization and demonstrated that the amino acids are not invariably the only building stones ever used by the organism. This in turn controverted facts established by all noted workers and effectually damned the particular investigation.

Therefore, our unknown investigator, after more than two years of zeal and after finding something entirely different from what he started out to find, was at last ready to risk publication. He could have rushed to print half a dozen times earlier and would have then produced the usual half-baked article.

But now, before his article can appear, the British *Biochemical Journal* arrives, announcing the isolation of glutathione from mammalian blood in the Cambridge laboratory of Sir F. Gowland Hopkins! Hopkins has rectified his error.

Our unknown therefore extracts what acrid satisfaction he can from his empty "confirmation" and tries to laugh. He finds later—so uncorrelated and overlapping is research—that two other investigators were directly on his heels. There they all were inefficiently groping separately, largely because a great and respected man had made a mistake and also because there is no world agency for effectively coordinating research.

So our investigator smokes meditatively, smiles sardonically, gathers up the pieces, investigates, sees where he is and starts afresh on some other corner of that immense problem—"The Mystery of Life." For the moment he is blocked by the fact that even his second valid discovery contravenes all accepted theories and will hence scarcely be accepted if he publishes it. Perhaps some new problem would be more fruitful anyway.

At any rate we see how he spends his time. So he proceeds from day to day. So he gropes and wanders. Of such is the kingdom of research.

INVESTIGATIONS OF LIFE IN THE SEA

By Professor W. E. ALLEN

SCRIPPS INSTITUTION OF OCEANOGRAPHY OF THE UNIVERSITY OF CALIFORNIA

There is no evidence that life in the sea is fundamentally or essentially different from life on land. The same laws of origin, distribution, maintenance and destruction are operative in both regions. Those differences in life in the two regions which attract our attention are differences in degree rather than in kind and are incidental to the character of the media in which the organisms are immersed. It is, therefore, reasonable to suppose that investigation of marine life may be, to a considerable extent, guided by knowledge and experience gained through investigation of the more easily accessible land and fresh water life.

The herdsman going into new country estimates its productivity by the vegetation spread before his vision. If his estimate be made from a single view he may be grossly deceived according to his presence in wet or dry season of the year or in wet or dry year of a climatic cycle or in a robust or diseased population of a biological cycle. In the history of our country many fortunes have been made and many have been lost on the basis of such single observations. Successful men are, however, disposed to reserve effort and expense until other views have been obtained. Having established himself in promising territory an intelligent herdsman then begins a series of more detailed studies of the conditions determining its productivity, the water supply, the plant succession, the animal migrations, the prevalence of pests, the indications of overloading and many others. For handling the details of such problems he soon finds himself incompetent through lack of ability, lack of time and lack of mental and physical equipment. He then seeks the aid of specialists who trace individual threads of influence in the fabric of condition and circumstance and who show, here and there, one that is harmful, another that is immediately and constantly valuable and another that is practically negligible. In most cases the success of a specialist in following a thread of influence is dependent upon his ability to forget every other thing and to concentrate his attention upon the ramifications of his particular thread. For that reason utilitarian aims in any biological research must receive scant attention except at the beginning or end of particular investigations, when they may suggest a problem or direct some application of its solution.

On account of the profound difficulty of carrying on investigations in the sea, due to expense, to limitations of space and time, and to obliteration of vision, the things which have just been mentioned are even more impressive than they are in connection with the work on land. The herdsman's single view of a landscape is vastly superior, as a basis of estimate, to a single visit of a fisherman to a locality of similar scope. Hundreds of items within the range of vision in open country contribute to the validity of a conclusion, none of which are available to the man who has little or no information beyond the catch (not the sweep) of his net. As a result the forward looking fisherman is more immediately dependent upon investigations by experts and specialists and the specialists are confronted with the necessity for high frequency and high continuity of

observations, both in space and time. Burdened with such necessities, the marine specialist, even more frequently than the land specialist, may be obliged to postpone consideration of the economic application of his observations until they have attained moment or definition sufficient to indicate so-called "practical results."

In the sea, no less than on the land, synthetic vegetation constitutes the basic link in the chain of sustenance of living things. In tide water, along shore, and on the bottom, algae and diatoms correspond to herbage on land. Floating in the water, diatoms and coccolithophores have such a relationship. Any effective biological survey of a marine region or locality must, therefore, as on the land, be based on a survey of the vegetation of its region, and no estimate of its productivity can have perennial or permanent value unless it includes careful estimates of the normal production of plants and of the annual range of production. Obviously, in consideration of the sharp and narrow limits of observation, the details of such problems can not be solved, or even stated, in terms of small magnitude.

Pending the development of investigations of large magnitude it is both desirable and necessary to make use of fragmentary and incomplete investigations, their application being subject to revision as expansion warrants. For example, it is pretty generally understood amongst marine biologists that certain organisms are so abundant, so widely distributed, so easy to study, and so important as links in the food chain, that they have great practical importance in estimating biological productivity in the sea. Most prominent amongst such organisms are diatoms, representing the plants, and copepods, representing the animals. Fortunately, both groups of organisms are known to have a close relationship to the welfare of fishes. Evidently, a good working knowledge of the numbers and successive shifts in numbers of these organisms in a given area and a record of the changes in kinds will give the best basis for developing an understanding of the conditions of productivity in that area. Records of numbers made from observations of high frequency and continuity resemble meteorological and astronomical records in the fact that their reliability and value increase as they perennially accumulate. Many biological problems which now seem hopelessly intricate may prove soluble after accumulation of records similar to those of astronomy.

On land, the ecological botanist or zoologist marks off a quadrat, selected by ocular inspection as typical of the local population, and in it makes a detailed study of the residents. In the sea this is not possible with the free living forms most favorable for quantitative study, and a fair estimate of the numbers and component forms of the residents can only be reached by a number of catches great enough to represent the whole area being studied. It is seldom possible to procure such numbers of catches and a larger or smaller percentage of error must be expected according to the number and spacing of the catches. Catches made frequently over a period of years or decades give ground for estimating the importance of this error and finally lead to a good general understanding of productivity.

As population increases and the demand for food and other natural products becomes more exacting, the assistance of experts in handling marine products is going to be needed to furnish the margin of safety in estimating marine productivity and the trend of good or bad influences on marine life. Consequently, it seems that the laying of the foundation of understanding of marine populations through accurate study of those forms most suitable for use as indicators of productivity and of the influences most prominent in influencing it is immediately important.

THE MONGOLIAN AGE OF MAMMALS

(MONGOLIA THE NEW WORLD, PART IV)

By Professor WILLIAM K. GREGORY
AMERICAN MUSEUM OF NATURAL HISTORY

THE geologists of the Third Asiatic Expedition of the American Museum of Natural History found in the Gobi region two major divisions of rock formations. Very large areas, Messrs. Berkey and Morris state, are covered with younger sediments that lie nearly flat. The strata themselves are simple and wherever they are disturbed the deformation is of comparatively simple type also—either gentle warping or, somewhat more rarely, sharp flexure and actual normal faulting. In all other areas much more complex rock formations are exposed, representing a more ancient floor which is doubtless continuous beneath all the sediments. This was the "Oldrock floor," in which, as we saw (Part I), the geologists found the much folded and metamorphosed remnants of very ancient rock series, often more or less penetrated and cut by granite or other igneous rocks. It will be recalled also that one of the formations in the Oldrock floor consisted of marine beds containing invertebrate fossils like those of the Permian age of China and Europe. Thus one at least of the components of the Oldrock floor could be assigned to its approximate position in the standard "geological column" of successive formations.

The "younger" sediments lying above the Oldrock floor and found in the separate basins of the Gobi region were not marine formations and thus contained no marine invertebrate fossils. How, therefore, could they be correlated with each other and with the standard marine series of Europe? But they did include in all some seven thousand feet of sediments heaped up by the rivers and winds and comprising about a dozen distinct horizons all containing vertebrate fossils. Thus Mongolia, like India, Europe, North America and South America, was found to have its paleontologic column of continental deposits of the Age of Reptiles and of the succeeding Age of Mammals. In all these other countries the paleontologists have sought to determine which horizons in different parts of the world were more or less contemporaneous. By comparing the history or evolution of related families in different parts of the world they have further sought to discover where a given family originated and by what routes it later became dispersed to various regions.

At the bottom of the Mongolian column of vertebrate horizons we find the Oshih (Ashile) formation, containing fossil teeth and vertebrae of a large sauropod dinosaur named *Asiatosaurus* by Professor Osborn and closely related to the huge *Camarasaurus* of Colorado (see Part II). In the same formation was found also the remarkably perfect skeleton of the small beaked bipedal dinosaur named by Professor Osborn *Psittacosaurus* (Part II). The presence of these reptiles has led Professor Osborn to correlate the Oshih formation with the Morrison or Lower Cretaceous of Colorado and Wyoming.

Considerably above this horizon comes the Djadokhta formation, which yielded

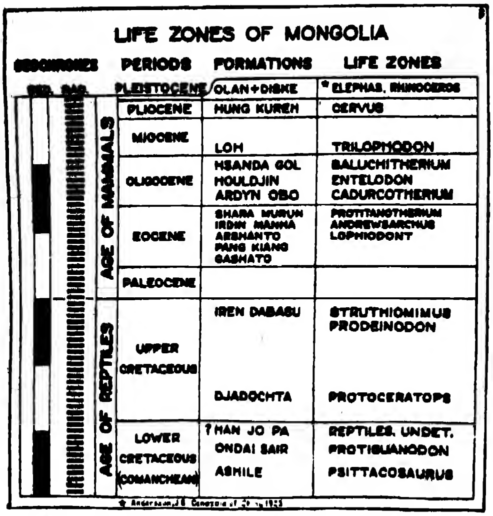
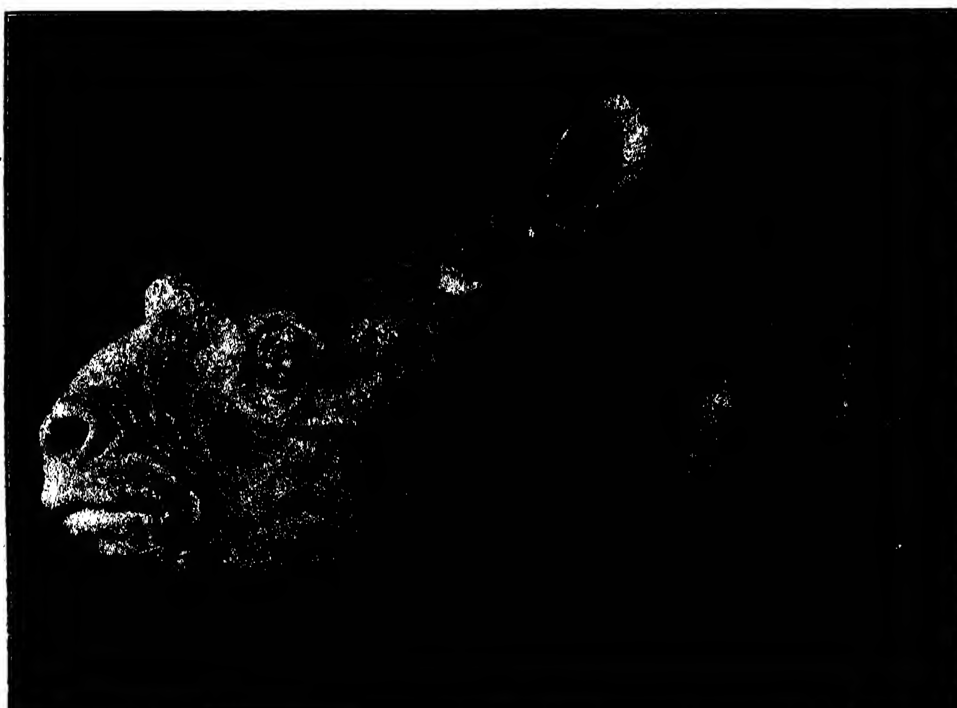


FIG. 1. LIFE ZONES OF MONGOLIA
BY STAFF OF CENTRAL ASIATIC EXPEDITION.

the famous collection of dinosaur eggs and skeletons (*Protoceratops*) and the priceless skulls of small mammals (Part III). These dinosaurs are distinctly smaller and more primitive than their huge relatives, the horned dinosaurs of the Upper Cretaceous of Montana and Alberta, and hence the Djadokhta formation is provisionally placed in the lower levels of the Upper Cretaceous.

The Djadokhta formation was subjected to a long period of erosion, but afterwards there was deposited upon it a series of two hundred feet of reddish and drab sediments to which the name "Gashato formation" has been assigned; this yielded a puzzling fauna of small and primitive mammals described by Dr. Matthew in 1925. Perhaps the most important specimen is a small



Photograph by American Museum of Natural History

FIG. 2. MODEL OF *PROTITANOTHERIUM* HEAD

MADE BY ERWIN S. CHRISTMAN UNDER THE DIRECTION OF WILLIAM K. GREGORY FOR PROFESSOR OSBORN'S MONOGRAPH ON THE TITANOTHERES. BASED ON THE FOSSIL REMAINS OF *Protitanotherium emarginatum* FROM THE UPPER EOCENE OF UTAH, CLOSELY RELATED TO *Protitanotherium mongoliense* OF THE GOBI DESERT.

Photograph by American Museum of Natural History

FIG. 3. *ANDREWSARCHUS* SKULL AND WOLF SKULL FOR COMPARISON

Photograph by American Museum of Natural History

FIG. 4. RESTORATION OF *ANDREWSARCHUS* BY E. R. FULDA

Protitanotherium IS SEEN IN THE DISTANCE.

Photograph by American Museum of Natural History

FIG. 5. RESTORATION OF *BALUCHITHERIUM* BY E. R. FULDA

lower jaw about an inch long, with molar and premolar teeth of a peculiar type which is fundamentally like that of certain extinct mammals of the Deseado formation of Patagonia. Fragments of upper jaws with teeth of the same species also have a distinctly "South American" appearance. Hitherto the only known fossil form of this general type found outside of South America has been a minute lower jaw from the Lower Eocene Wasatch formation of Wyoming, previously described by Matthew. Thus Mongolia, Wyoming and Patagonia seem to be on the dispersal route of these strange little mammals. But in which direction did the dispersal take place?

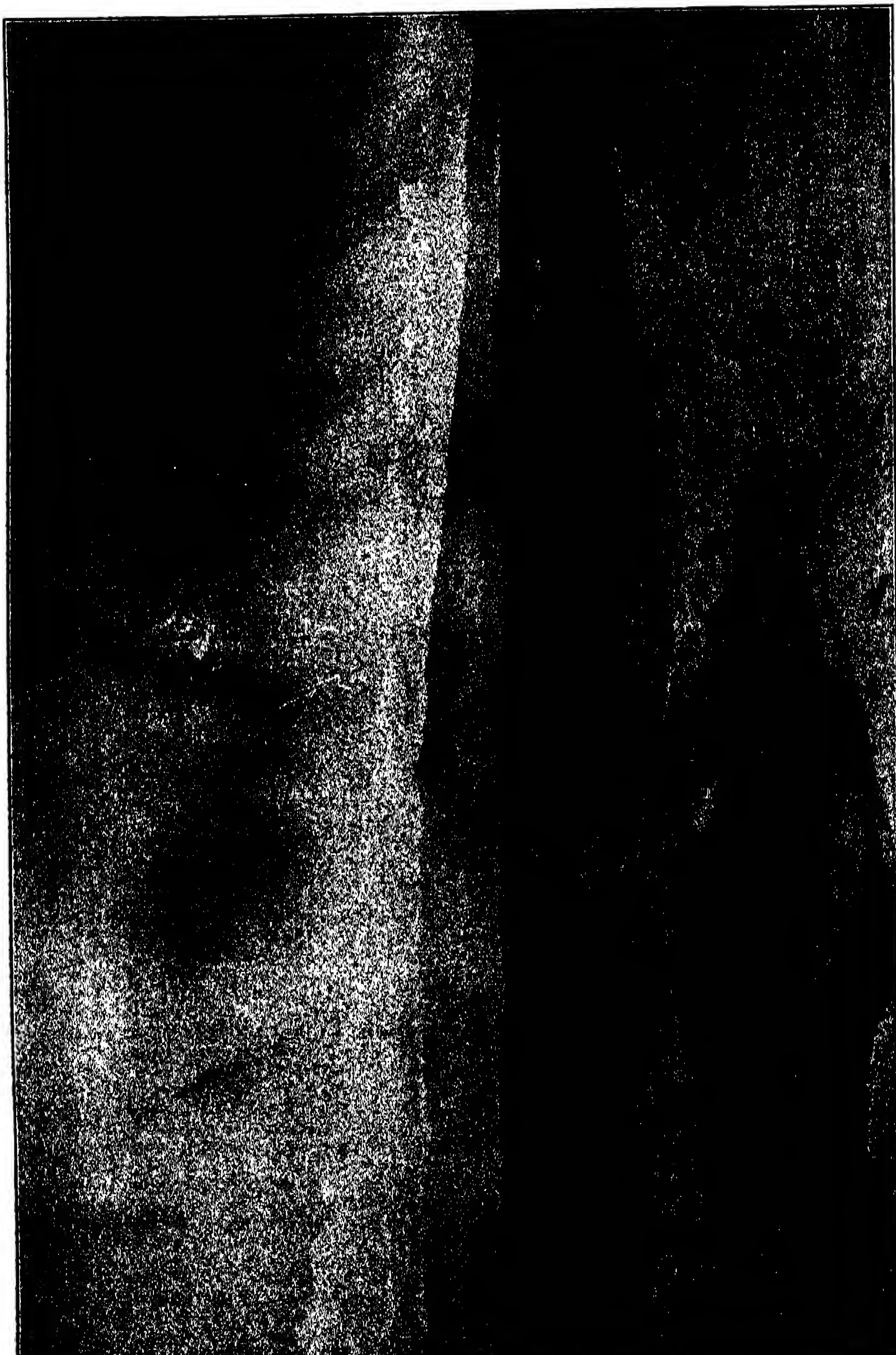
All the fragments of jaws and teeth found in this formation are peculiar in one way or another, but as a whole they appear to suggest a Basal Eocene (Paleocene) age. They tend also to strengthen Dr. Matthew's view that the stem forms of the whole series of South American orders, which dominated that region for millions of years, might be traced back eventually to still earlier and less specialized ancestral stocks originating in the Northern Hemisphere before the route to South America was cut off.

Above the Gashato formation there follows apparently a considerable break in the record, representing all the great mammalian faunas of Lower and Middle Eocene age in Europe and North America, no trace of which has thus far been found in Mongolia. The history is resumed in the Irdin Manha formation, from the type locality of which a large collection of fossil mammals was obtained. Here were several kinds of small lophiodonts and related hoofed animals that were allied to the tapirs on the one hand and to the rhinoceroses on the other. Many allied forms have been found in formations of Eocene age in

Photograph by American Museum of Natural History

FIG. 6. SKULL OF *BALUCHITHERIUM*

FOUR FEET, TWO INCHES LONG.



Photograph by American Museum of Natural History

FIG. 7. EXPOSURES OF HSANDA GOL AND OVERLYING LOH BEDS

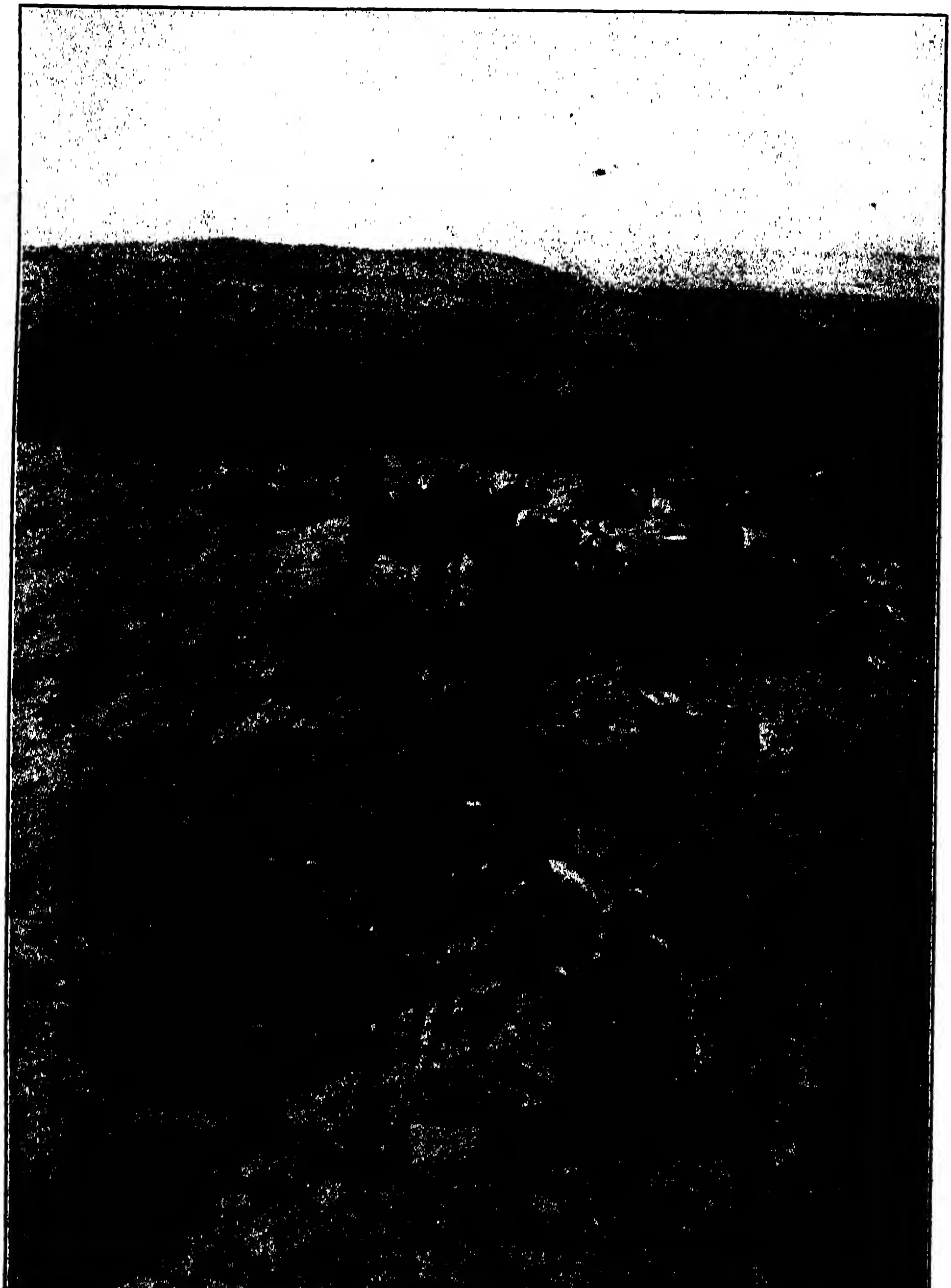
Europe and Western North America but for the most part, at least, these Mongolian forms were not directly ancestral to either their European or their American relatives. The relationship, however, is sufficiently close to establish the fact that there had at some time been some route or pathway between these widely distant regions.

This view is fully confirmed by the presence in this Irdin Manha formation of a great number and variety of titanotheres. This peculiar extinct family of hoofed animals in North America extended from the Lower Eocene through the Middle and Upper Eocene to the close of the Lower Oligocene, during which time the family was represented by nearly two hundred known species, ranging from very small primitive hornless forms in the Lower Eocene up to the gigantic animals with a transverse pair of "horns" above the eyes in the Lower Oligocene. At that time these animals were extremely abundant in what is now the "bad land" region of South Dakota and Nebraska, and their fossil remains were ascribed by the Indians to the legendary "thunder horse." The numerous Mongolian titanotheres of the Irdin Manha and of the succeeding Ardyn Obo formations show the most striking resemblances to the related forms of corresponding horizons in North America. So far no trace of the older Middle and Lower Eocene titanotheres, which are so abundant in the Bridger and Uinta mountain basins of Wyoming and Utah, have been found in Mongolia and in this case the evidence at first suggests that the earlier stages of the family were passed through in western North America, and that the family spread thence to Mongolia, one or two representatives penetrating also to Western Europe.

These peaceful herbivores of the early Mongolian forests and plains were preyed upon by an assortment of carnivores which are plainly related to those of similar age in Europe and North America. Easily the chief of these was the huge *Andrewsarchus*, with a skull thirty-three inches long. Professor Osborn, who described this skull, tells us that "This is the largest terrestrial carnivore which has thus far been discovered in any part of the world. The cranium far surpasses in size that of the Alaskan brown bear (*Ursus gyas*), the largest living carnivore, which, when full-grown, weighs 1,500 lbs.; in length and breadth of skull, *A. mongoliensis* is double *Ursus gyas* and treble the American wolf (*Canis occidentalis*). It is also treble the size of its American relative *Mesonyx obtusidens* from the Middle Eocene of Wyoming and double that of *Mesonyx* (*Harpagolestes*) *uintensis* from the Upper Eocene of northern Utah, Uinta B."

The three-toed horses, so characteristic of North American horizons of equivalent ages (Upper Eocene and Oligocene), were conspicuously absent so far from the Mongolian record, while the paleotheres, numerous in the Eocene of Europe, were likewise unrepresented. As yet no one knows why these families were absent or why the horses apparently did not reach Mongolia until Pliocene times.

The Hsanda Gol formation, also of Oligocene age, contains one of the most extraordinary fossil animals ever discovered, the gigantic rhinoceros *Baluchitherium*. Formerly discovered by an English paleontologist, C. Forster Cooper, in Baluchistan, and found also by the Russians in Turkestan, the American Museum expedition was highly fortunate in securing a nearly complete skull and parts of the skeleton of this amazing animal at Hsanda Gol in the western part of the Gobi region. The skull is



Photograph by American Museum of Natural History

FIG. 8. RECOVERING AND PHOTOGRAPHING A FOSSIL ELK ANTLER

not less than four feet, two inches long and the column-like hind foot measures more than three feet from the heel to the ground. The estimated height at the shoulder is about thirteen feet, higher than the tallest elephants but less massive.

Under the feet of this titanic animal scampered a remarkable profusion of rodents, some related to the queer gopher-like rodent *Bathyergus*, others to the squirrels, dormice, rats and mice and pikas, all of which have been identified and named in papers by Dr. Matthew. Students of the evolution of these teeming groups will find much of interest in the Mongolian fossils.

In the Loh formation, a thin deposit lying above the Hsanda Gol, the long-jawed mastodons arrive, represented by a relative of the European *Mastodon angustidens*. This formation is referred by Professor Osborn to the Lower Miocene. A rhinoceros from this formation has the molar pattern more advanced than that of *Baluchitherium* and appears to be related to one of the true rhinoceroses of the Miocene of Europe (Matthew).

The Hung Kureh formation, succeeding the Loh formation, marks the first appearance of the horse in this region. It also contains deer and ostrich remains and apparently represents the Pliocene epoch.

Later than the Hung Kureh formation is the loess of China (fine wind-blown dust, more or less consolidated). This, with other formations, represents the long period which in Europe and North America witnessed the slow advances and retreats of the great continental ice sheets. The glaciers, however, never invaded Mongolia.

Accordingly, the Mongolian record of the Age of Mammals has thus far brought to light several new and strange forms, as the gigantic carnivore *Andrewsarchus* and the still more gigantic *Baluchitherium*. Apart from such novelties, it shows many striking elements of affinity with the well-known fossil faunas of North America, Europe and India, so that there can be no question that at least at times there was a free land passage between western North America, Mongolia and western Europe. The Mongolian animals may have spread eastward over the Behring Straits route into northwestern North America; by travelling westward they would find their way into western Europe; southward they would soon have reached India and Burma.

Thus it is tempting to look to Mongolia as the Garden of Eden for every one of the higher mammalian families, from mice to men, and to think of every group as originating in Central Asia and dispersing toward the southeast, south and southwest. But very probably the facts are far too complex to fit any such simple explanation. In the case of the titanotheres, for example, the earliest very small and primitive members of the family appear in the Lower Eocene of North America, immigrants from some still unknown region. Professor Osborn, assisted by the writer, has shown that at every known horizon in North America, from the Lower Eocene to the close of the Lower Oligocene, we meet with the more and more modified descendants of the earlier inhabitants of a given region, together with new types that appear to be immigrants from some other quarter. Certain genera of the Upper Eocene titanotheres of both Mongolia and North America (*Dolichorhinus, Telmatherium, Protitanotherium*) appear to be the direct descendants of earlier titanotheres in the Middle Eocene of North America

Photograph by American Museum of Natural History

FIG. 9. WALTER GRANGER EXCAVATING A FOSSIL RHINOCEROS SKULL, 300 MILES SOUTH OF URGA.

(*Mesatirhinus, Telmatherium cultridens, Manteoceras*). In the case of the titanotheres it appears that the dispersal took place at first in one direction and then in another, and the same appears to the writer to be true of the mesonychid, oxyaenid and hyaenodont carnivores, also of the amblypods, lophiodonts, amynodonts, true rhinoceroses and certain artiodactyl groups.

But what we already know of the Mongolian life record is obviously only the promise of what is to come, if Roy C. Andrews, the Ulysses of paleontology, succeeds in getting his expedition into the field this year.

Photograph by American Museum of Natural History

THE LIFE HISTORY OF THE FISH ASTROSCOPUS (THE "STARGAZER")

By Professor ULRIC DAHLGREN

PRINCETON UNIVERSITY

IN the littoral waters of our Atlantic coast lives a fish, commonly called the Stargazer, *Astroscopus,* whose life history, relationships and adaptation to its environment are so remarkable that the writer, who has studied it at intervals for over twenty years, thought the story ought to be told, especially as so few people know the fish or even suspect its remarkable history.

In 1884 attention was first called to the animal by reports that it was capable of giving a rather strong shock of electricity, and an examination of an alcoholic specimen kindly sent from the U. S. National Museum soon showed that an electric organ of a new type was present. The studies that followed brought the writer into such close and intimate contact with this fish that other equally interesting facts were brought out and upon them rests the following account.

The fish belongs to a very large group of fishes, the order Acanthopteri, which is so heterogeneous and large in its composition that this position does not signify much as to the relationships of the stargazer. The more immediate and smaller sub-group to which it belongs is a division of the fish world known as the "Trachinoidea" or "sand fishes." In the several families of this group we find many genera and species which, aside from the more technical features of their internal anatomy, clearly show a blood relationship. They show, more or less plainly, easily observable external features of form, color and structure which go to demonstrate that the major portion of all the genera and species have an inclination to live on a sand bottom and, more specifically, to live very close to the sandy bottom or even *in the sand.* Even further than this, to live in the sand in a *certain way or manner.*

Many other fishes or whole groups of fishes have developed the ability to live in or on the sand, as the little silvery sand eels, *Ammodytes,* which dive into it and burrow through it with their sharp noses and long eel-shaped bodies; or as the flounder tribe, which have turned over on right or left side, developed a protective coloration and a secondary bilateral symmetry and long fins on the two sides (once the dorsal and ventral edges) with which they can glide over the bottom or even, by a peculiar flopping motion, quickly bury themselves completely in the mud or sand. Again, the skates and rays, instead of lying over on one side to take advantage of the natural lateral flatness of a fish's body, as the flounders have, are flattened dorso-ventrally to produce a flat form so that they can act much in the way that the flounders do.

While many of these other general groups have attained a considerable adaptation to living on sandy bottom, and a skill in burying in the sand, these features have reached their climax in *Astroscopus* (Fig. 1) and will now be described in connection with an account of the habits of the fish. It is notable that this fish has attained these adaptive structures without noticeably altering its general "fish-like" form from that found in a sculpin or toad fish.

Astroscopus does not move around

FIG. 1. PHOTOGRAPH OF A SIX-INCH *ASTROSCOPUS GUTTATUS*

FROM BEAUFORT, N. C. THE OUTLINES OF THIS SPECIMEN ARE SOMEWHAT MORE ROUNDED THAN THEY WILL BE WHEN SUCH A FISH IS ADULT AND THE FINS ARE PROPORTIONATELY LARGER. NOTE THE CURLED UP EDGE OF THE PECTORAL FIN WHICH IS USED TO LEAD AWAY THE RESPIRATORY WATER FROM THE GILLS WHEN THE FISH IS BURIED IN THE SAND. ALSO THE SPOTS ARE LARGE FOR THE TYPICAL *Astroscopus guttatus.* COMPARE THEM WITH THE SPOTTING OF THE SKIN SEEN IN MORE NORTHERN SPECIMENS (SEE FIG. 5). THE SPOTS ARE ALSO SMALLER THAN THE SPOTS IN A TYPICAL SPECIMEN OF *Astroscopus y-graecum* FROM FURTHER SOUTH (SEE FIG. 11). PHOTOGRAPH BY C. W. SILVESTER FROM A SIX-INCH BAY FISH.

much except when migrating and then swims slowly and clumsily. When he stops he comes to rest, always on sandy bottom and at once begins to squirm with short, side-to-side motions of his ventral surface and tail, holding the caudal and anal fins rigidly so that these fins begin to open up a trench into which the body sinks. At the same time the two large strong pectoral fins and the ventral fins begin to perform an outward shovel-like motion which digs a hole rather than a trench under the heavy forward part of the body.

The animal keeps up this motion while resting on its belly in a horizontal position and in that position it sinks directly downward. This action is guided in its rapidity by circumstances. If undisturbed and not pursued the side-to-side motions are each about a second in duration, the sand is pushed aside and when about two thirds under the surface the animal stops and rests (Fig. 2), resuming in a few moments and carrying the process to a point where only the front tip of the head and possibly the upper tip of the caudal fin are visible (Fig. 3). If frightened and seeking to escape, however, it alters this procedure. It rushes forward and doubles on its path several times, often executing one or two clumsy somersaults near the bottom to stir up the sand and hide its movements, then, suddenly straightening out in a horizontal position, it vibrates and digs as described, so violently and quickly that by the time the sand has settled it has disappeared beneath the surface. It may go down for as much as twelve inches or more. The writer once spent a beautiful October afternoon wading along Buckrow beach near Old Point Comfort, Virginia, in about three feet of water on a clean sand bottom, and, among the other fishes seen, were seven stargazers. All were concealed just under the surface of the sand and when touched with the boot or net handle sprang out of the sand, dashed off about a dozen feet and

went through this performance. Five of these were captured by the bare hand which was pushed down in the sand at the spot where the animal had sunk until the fingers could be closed tightly around the still burrowing fish, now six or more inches below the surface, which was then drawn out and carried ashore. One of them got down fully twelve inches in the loose sand before capture and two were not found, either because too deep or because it had not been possible to properly locate the spot where they sank. One kept in the Washington Aquarium was nearly always half buried in the sand (Fig. 2) or just under the surface with a small patch of the upper head showing. The next photograph (Fig. 3) was taken from above of a living stargazer in the sand at Beaufort, N. C. This fish had been in this same position all day but came out and moved about some in the evening.

The first adaptation to be mentioned, a slight one, is in the general shape of the body, particularly the flattened upper surface of the head, which surface extends out as a plane to the extreme tip of the snout, making the front of the anterior end blunt and enabling the whole body to be just submerged so that mouth, nostrils, eyes and other organs, while almost concealed, are still at the surface.

The second adaptation is the development of caudal, anal, pectoral and ventral fins to a strength and position in which they can do the digging (Fig. 1). The ventral fins also have been moved forward where they will best assist the pectorals in burying the head. In connection with this there are undoubtedly nerve reflexes and coordinating mechanisms established that operate these various motions for their most efficient work.

The third adaptation, that for sight, lies in the anterior position of the eyes and their position on the flat top of the head. Not only this, however, for the eyes can be moved up and down so that they either protrude a short distance to see above the very thin covering of sand or lie flat in their sockets. This appears to be accomplished by the filling of the tissues back of the eye with some body fluid, so that they arise on short stalks for as much as one quarter of an inch. The writer has also seen this eye raising in flounders, skates, gobies and other bottom fish that live on the bottom or bury in sand or mud. It is not present in most fishes.

The fourth adaptation is an extensive and somewhat complicated organization of parts of remarkable interest and is connected with the breathing of water. It must be considered in detail as several

FIG. 2. PHOTOGRAPH OF A LIVING *ASTROSCOPUS GUTTATUS*

HALF BURIED IN THE SAND IN THE AQUARIUM IN WASHINGTON. CAPTURED AT NORFOLK, VA., AND SHOWS THE FINE-SPOTTED PATTERN OF THE TYPICAL NORTHERN STRAIN. FROM D. S. JORDAN'S BOOK ON FISHES AFTER A PHOTOGRAPH BY DR. R. W. SHUFELT FROM A TWELVE-INCH BAY FISH.

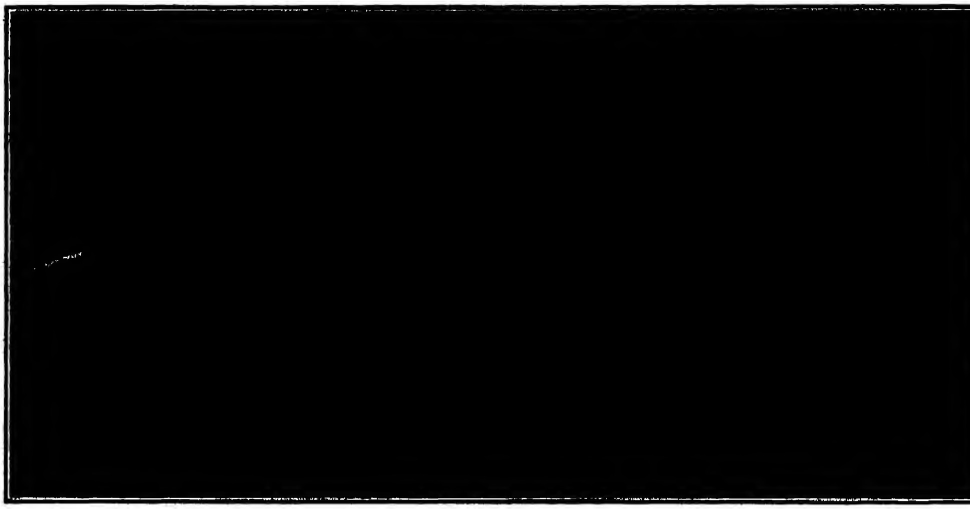


FIG. 3. PHOTOGRAPH OF A LIVING *ASTROSCOPUS GUTTATUS* BURIED IN THE SAND AT BEAUFORT, N. C. THE TOP OF THE HEAD AND UPPER TIP OF THE TAIL ARE ALONE VISIBLE. HALF WAY BETWEEN HEAD AND TAIL NOTE THE TWO SMOOTH SPOTS (x) ONE ON EACH SIDE, WHERE THE GRAINS OF SAND ARE DANCING IN THE TWO CRATERS THROUGH WHICH THE RESPIRATORY STREAM OF WATER IS PASSING UP FROM THE TIPS OF THE PECTORAL FINS BENEATH. PHOTOGRAPH BY C. W. SILVESTER FROM A SEVEN-INCH BAY FISH.

interrelated items. First, the fish has developed the very unusual structure of a connection between the narial cavity and the pharynx. In all but *Astroscopus* and one or two other forms of fish the narial chamber has no connection with the mouth cavity but opens to the exterior by two small holes on the outer surface of the head, one opening situated at the anterior end of the chamber and provided with an erect flap of integument so placed as to direct the water into the chamber as the fish swims forward, the other usually posterior to this and designed to allow the water to flow out, thus establishing a current through the chamber for testing the odors in the water by the chemo-receptive nerve endings situated therein. In such case no water can pass from the narial cavity into the pharynx and in consequence most fish can not breathe through their noses.

The narial cavity of *Astroscopus* opens on the outside of the head (Fig. 4) by the usual two holes, but in addition it also opens downward into the large pharynx by a passage of considerable size. What, then, is the course of any water currents? In order to explain this we must first describe the act of breathing which is common to all teleost (bony) fish.

In every such fish the large mouth cavity or pharynx opens anteriorly by a wide lateral slit, the mouth, and posteriorly by two symmetrical and vertical slits known as the gill openings. The sides of this cavity are composed of two large, thin and stiff structures of bone, connective tissue and skin known as the opercula, whose posterior edges form the outer edge of the gill slits. These opercula, hinged on their anterior edge, where they are connected with the skull, are provided with powerful muscles which move them synchronously inward and outward, thus alternately enlarging and contracting the capacity of the pharynx.

When the opercula open, water comes in freely at the mouth but is prevented from coming in at the gill slits by two loosely hung valves called the branchiostegeal membranes, which are hung loosely on the opercula.

When the opercula close, water passes freely out of the gill slits while it is prevented from returning through the mouth by two thin, membranous semilunar shaped valves, the mandibular and maxillary valves, which snap into place in the current and keep the water in.

Thus we have a two-valve pump with

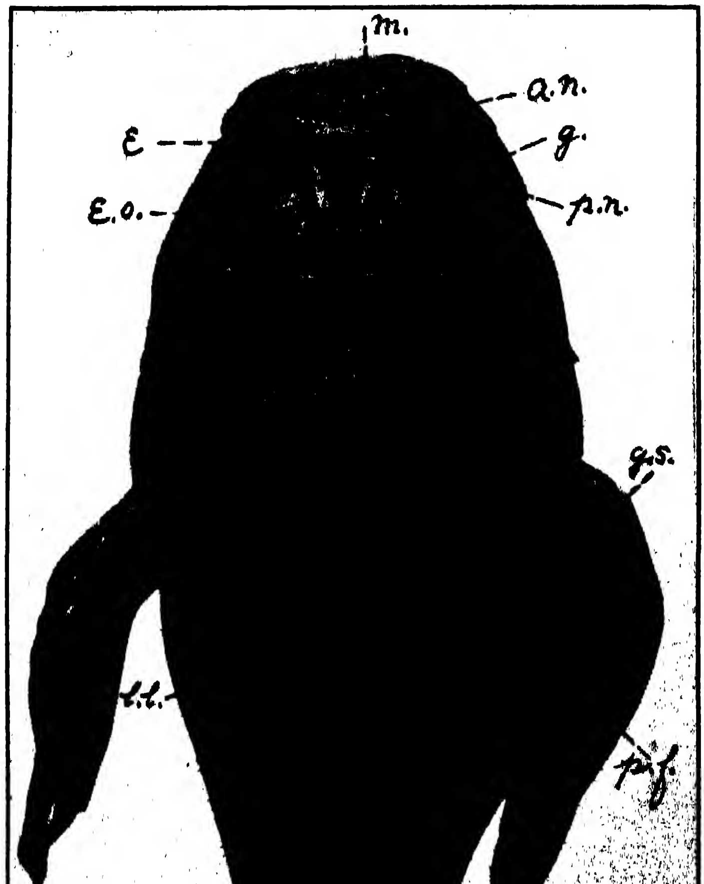


FIG. 4. VIEW FROM ABOVE OF A PRESERVED SPECIMEN OF *ASTROSCOPUS GUTTATUS*

FROM NORFOLK, VA., TO SHOW THE EXTERNAL FEATURES OF ADAPTATION—(E) EYES; (A.N.) ANTERIOR NOSTRILS; (P.N.) POSTERIOR NOSTRILS FROM WHICH THE FILAMENTED GUARDED RESPIRATORY GROOVE (G) EXTENDS BACKWARD AND OUTWARD; (M) MOUTH WITH ITS INTERDIGITATING SIEVE FILAMENTS TO KEEP THE SAND OUT OF THE RESPIRATORY STREAM; (G.S.) GILL SLITS, PROLONGED BACKWARD TO REACH THE BASES OF THE PECTORAL FINS (P.F.) WHOSE OUTER EDGES CURL UP TO PROVIDE A TUBE-LIKE CHANNEL THAT WILL CONDUCT THE EXHALENT RESPIRATORY STREAM TOWARD THE SURFACE OF THE SAND WHEN THE FISH HAS BURIED ITSELF; (E.O.) OUTLINE IN INK TO SHOW THE EXTENT OF THE ELECTRIC ORGAN; (L.L.) LATERAL LINES. A TWELVE-INCH BAY FISH.

the water running backward from mouth to gills in response to the bellows-like action of the opercula and the action of the two pairs of valves. The gills are in this way always supplied with new salt water carrying the oxygen they need for the animals' respiration.

Now we can examine the action of the naso-pharyngeal passage of *Astroscopus* mentioned above. When the opercula expand and water runs in at the mouth in *Astroscopus* it also comes into the pharnyx from the nose through this passage. When the opercula close this water is prevented from running back into the nose by a pair of small membranous valves, one on each pharyngeal end of the two passages. These we must call the two narial breathing valves.

We can now see that the stargazer could breathe through his nose alone, perhaps more slowly but in considerable volume. And he does. The two double nose openings may be free when the mouth is covered by sand.

In the second place *Astroscopus* has still another adaptation in connection with his breathing intended to enable him to breathe when the water is full of flying sand or even when he is buried in loose sand, without having any of this sand drawn into his pharynx. This consists of a row of fine, comb-like serrations on the edge of each jaw, placed so that when the jaws close these fleshy serrations (Fig. 4, m.) interdigitate. A sieve is thus formed that keeps the sand out but lets the water in and, by opening the jaws slightly, he can let in more water when the sand grains are larger, or by closing his jaws further he can keep out the finer grains at the expense of not getting so much water.

The two nose openings on top of the head are also armed with these same, fleshy, comb-shaped fringes. In the case of the small, round, anterior opening this fringe forms a blunt rosette (Fig. 4, a. n.). In the case of the posterior opening (Fig. 4, p. n.) another feature is added. The narial channel, where it comes to the surface of the head, bends over at nearly right angles and forms a long trough or groove whose two upper edges bear a row of the serrations (Fig. 4, g.). In this instance a great deal of water can filter into this groove, more than could flow into a round opening guarded by the serrations and as much as can pass rapidly from the narial cavity down through the naso-pharyngeal tube into the pharynx for respiratory purposes. This modification makes nose breathing a practical feature of the life of *Astroscopus* even when buried in the sand. Many of our own engineering feats in constructing municipal water works are not so well planned.

One more double feature of this fourth adaptation is to be seen in the breathing apparatus of this wonderful fish. This is found in connection with the disposal of the water after it has been used in breathing. The water is not expelled directly into the surrounding sand. We find that the gill slit (Fig. 4, g. s.) is narrowed and drawn backward and upward into a short, loose, baggy tube. This carries the waste water a short way through the surrounding sand. This tube ends near or next to where the great pectoral fin begins (Fig. 4, p. f.). Now the pectoral fin is the most powerful digging machine that the fish possesses, but when the digging is completed the fin remains with its distal end cocked up so that the tip is above the level of the back and the outer fin edge is thin and soft. This edge is curled over into a rounded, closed or partly closed tube (Fig. 1) and this tube communicates with the gill tube so that the waste water is carried still further up through the sand in this channel and discharged from the tip of the fin. In the figure one can see, directly over the tips of the two pectoral fins, two tiny craters in the sand (see Fig. 3, x.). At the bottom of each

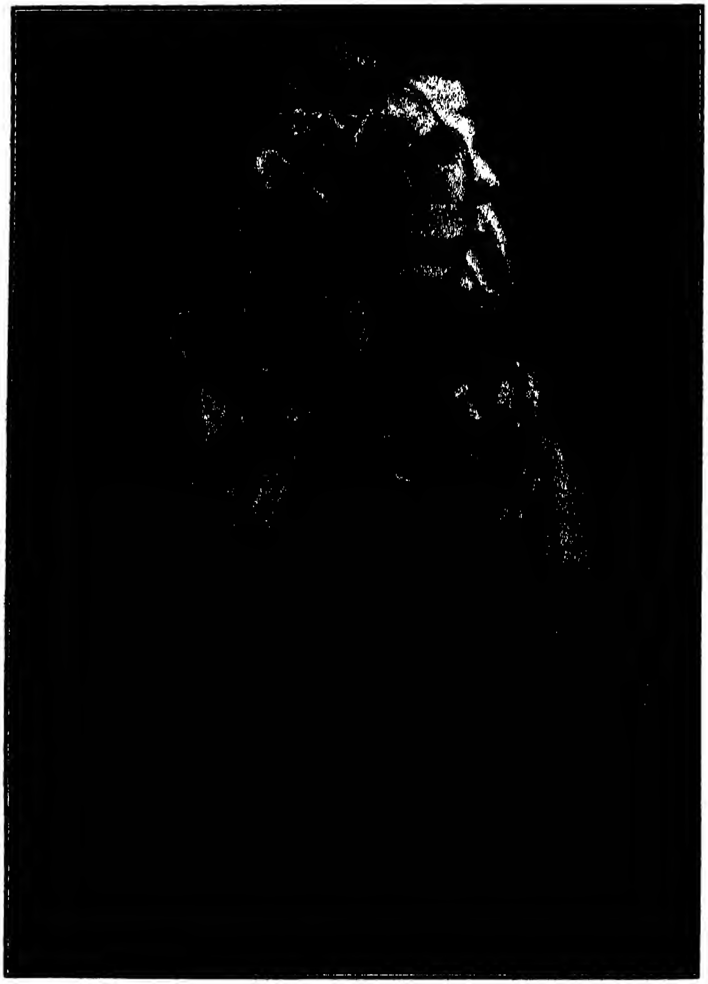


FIG. 5. A PRESERVED SPECIMEN OF *ASTROSCOPUS GUTTATUS* (NORTHERN, FINE-SPOTTED TYPE FROM NORFOLK), SHOWING THE ELECTRIC ORGAN DISSECTED OUT ON THE RIGHT SIDE AND WITH THIS ELECTRIC ORGAN DISSECTED AWAY TO SHOW EYE MUSCLES, NERVES AND BLOOD VESSELS OF THE REGION ON THE LEFT SIDE. BOTH EYES IN POSITION. PHOTOGRAPH BY C. W. SILVESTER FROM A FISH ELEVEN INCHES LONG.

crater, over a live fish, a close examination will show the sand grains dancing up and down continuously as they do in the sandy bottom of many springs where the water is welling up.

The fifth adaptation consists of a decided change in the position of the lateral line. The lateral line of bony fishes is an open groove or more often a closed groove or tunnel (Fig. 4, l. l.) opened to the exterior by a series of holes or tubes placed in various symmetrical positions. In this groove or tunnel are sense organs of some unknown function. Various functions have been argued from the perception of sound to the reception of chemical stimuli. This latter may be true.

Whatever this sense may be, it is clear that in a fish that lives buried so long in

the sand, it would be of advantage to have this organ nearest to the surface of the sandy bottom in which it lies buried. In most fish the line pursues a straight direction or gentle curve on each side of the body, often with a sharper upward detour in its anterior end. In *Astroscopus* the lateral lines, beginning well up on the gill opening on each side, run upward at a sharp angle until the two lines lie almost together, one on each side of the dorsal fin or, where there are no fins, on each side of the median dorsal line (see Fig. 4, l. l.). This brings them into a position where they are nearest to the open water and on a part of the body that is last buried when the fish goes into the sand. In fact, most of the fish's time is spent with the top of the head and median dorsal line just level with the sand so that the lateral line is near enough to the surface to operate. This is clearly an adaptation to its habits.

The sixth and last adaptation to the fish's life in the sand is probably a more radical and deeper seated one than any of the others. This is the ocular electric organ which gives off from the eyes and their neighborhood a shock of painful intensity.

In Fig. 4 one can see two rounded oblong areas of considerable size just behind the two eyes. An ink line indicates the limits of one of them. If the skin be removed from the head (Fig. 5) these areas will be seen to represent two wide deep wells in the skull, which pass downward with the same diameter until they open into the mouth cavity, but shut off from communication with this by the skin of the roof of the mouth. In life each well is filled with a mass of grayish, semi-transparent tissue which is the source of the electric discharge.

On microscopic examination of a vertical section of the electric tissue it can be seen that each of these electric organs is composed of about two hundred layers (Fig. 6) of evenly spaced horizontal layers (in a horizontal section it can not be observed) and that each of these layers is constituted by about twenty smaller plates lying side by side (Fig. 7) and of somewhat irregular shape and size, all moulded together to form the regular shape and size of the larger unit which has been called the *electric layer*, while the smaller units of which its lateral extent is composed may be designated the *electroplaxes*.

All electroplaxes have a smooth upper surface and a papilla studded lower surface. These papillae are for the purposes of affording a greater surface for

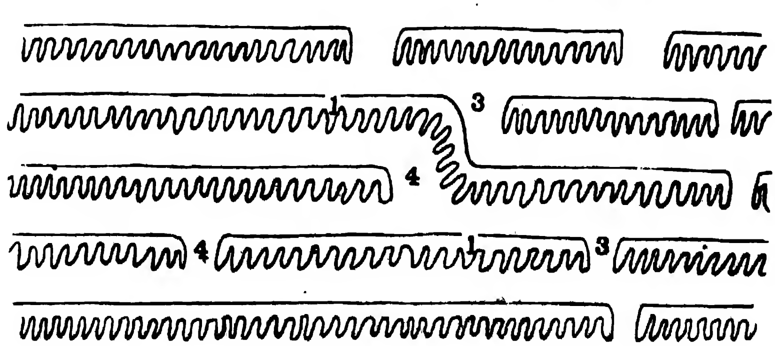


FIG. 6. DIAGRAMMATIC VIEW OF PART OF A VERTICAL SECTION OF THE ELECTRIC TISSUE OF *ASTROSCOPUS*

TO SHOW THE ALIGNMENT OF THE HORIZONTAL ELECTRIC LAYERS. THERE ARE ABOUT TWO HUNDRED LAYERS IN EACH ORGAN IN A FISH AT ALL STAGES OF ITS GROWTH.

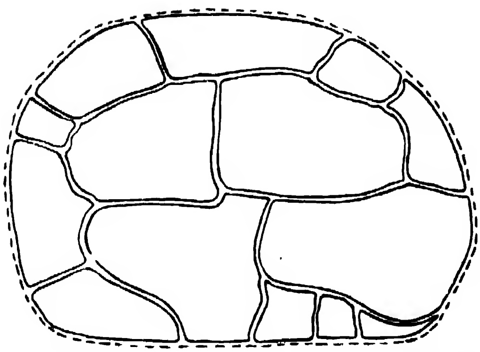


FIG. 7. DIAGRAMMATIC VIEW OF THE TOP OF ONE ELECTRIC LAYER OF *ASTROSCOPUS* TO SHOW ITS CONSTITUENT ELECTROPLAXES.

exchanges with the blood vessels that are in contact with them and this lower surface may be spoken of as the nutritive surface. The smooth upper surface is studded with thousands of nerve endings formed by the branching ends of a few nerve fibers that come in between each pair of electric layers. The substance of each layer (and its constituent electroplaxes) is striated much as muscle substance is, only the striations are not straight and parallel as in muscle but curved and parallel. We shall see later, as is known about some of the other electric fishes, that each electroplax represents a single muscle fiber. Some of the other electric fishes, as *Electrophorus,* the electric eel, and *Mormyrus,* form each electroplax from several muscle cells instead of from one.

The upper surface of this entire organ represents the negative pole of a source of E. M. F. and the lower surface represents the positive pole. Consequently lines indicating the field of discharge and current during the shock would run from upper minus surface to lower plus surface or down through the organ and from plus around to minus or up outside the organ.

The organ is supplied by fibers from the third or oculomotor nerve whose motor centers in the brain show the usual very large nerve cells found in connection with all electric organs.

One remarkable and puzzling arrangement in connection with the apparatus is the position of the eye and the arrangement of its six muscles and the optic nerve with reference to the mass of electric tissue. The six muscles and the optic nerve reach into the eye socket or electric chamber from the lower and posterior edge of the organ and the eye is over the upper anterior edge (Fig. 5). In order to reach the eyeball they must and do pass for long distances through and around this bulky mass of tissue. What morphological significance has this electric tissue?

First, we know that most electric tissue originates from muscle, and the only muscles in such a locality in *Astroscopus* that could easily form it are the eye muscles. We also know that the third or ocular motor nerve supplies motor stimulus to only certain of the eye muscles and we see here that the electric tissue is supplied with a large branch of this nerve. Both these facts point strongly to one or more of the eye muscles as the source of the electric organ and yet all eye muscles are present, apparently perfect, and are innervated by their proper nerves, the third, fourth and sixth cranial nerves.

Secondly, when first studied, it seemed that this organ might have been developed in early embryonic life from one of the group of three palatine muscles which lay almost next to it, particularly the levator arcus palatini, or from the adductors mandibulae which touched it at another point. This supposition, however, seemed not quite so probable as the eye muscle theory on account of certain arrange-

ments of nerves and arteries which supplied both these muscles and the electric organ.

The best logical supposition that could be entertained, therefore, seemed to be that the electric organ was derived by an unusual modification of a portion of one or more of these eye muscles and since the electric organ was innervated by branches of the third nerve exclusively it was surmised that the muscles involved were one or more of those served by the third nerve, namely, the inferior oblique, internal rectus, superior rectus and inferior rectus. It was not considered that the superior oblique or external rectus could have been involved because they are always supplied in *all* vertebrates by the fourth and sixth cranial nerves, respectively, and these nerves showed no signs of being involved with the electric tissue.

This puzzle could only be solved in one way, it became very evident, and that was by a study of the embryological history of the parts involved. To do this it was necessary to have certain stages of the development of *Astroscopus,* and no one had ever seen a young *Astroscopus.* Nor did any questions addressed to the U. S. Fish Commission, to native fishermen and to others who had observed the fish throw any light whatever on its breeding habits.

The writer determined to get this knowledge and the whole story of how he finally succeeded makes such a typical account of the methods that must often be employed in biological work that it will be related here.

Up to this time the fish had been secured in the summer and fall from trap nets or pounds in the lower part of Chesapeake Bay, only about two dozen in all. Such fish were fairly large, from eight to twelve inches or more in length and were considered fully adult. It seemed a very easy matter to dissect some of these fish and to get considerable information from a microscopic examination of their ovaries in order to tell something about when they bred and, possibly, how they deposited their eggs and even where the eggs were laid.

It may be said here that teleost fish in general have two types of breeding. The first is to throw out into the water a vast number of very small eggs, sometimes several million in number, which are transparent in color and which would sink to the bottom were it not for the fact that many of them possess in their mass one or more globules of oil which, by virtue of the low specific gravity of oil or of the egg itself, cause the whole egg to rise to the surface where development takes place and the young fish hatches and then, after a short larval life on or near the surface of the sea, descends to the bottom, if its parents are bottom-living fish, and spends the rest of its life there. In size such eggs are seldom over two millimeters in diameter, usually much less, and the young fish as well as the egg are both transparent, since probably only such could escape their enemies in sufficient numbers to keep up the numbers of their kind. This is called the *pelagic method* of breeding, since it usually takes place far enough out at sea to prevent too many of the eggs from drifting ashore before they hatch. It is a dangerous method, and vast numbers of the eggs and larval young are lost by being eaten by such fish as mackerel and menhaden, which systematically sift the surface waters through their net-like gill rakers to get them. So the eggs *must* be small and transparent in order that they may be sufficiently numerous and inconspicuous for enough to survive. Many bottom-living fish breed by the pelagic method, as flounders, gurnards, cod, etc.

The other part of the fish world lays its eggs on the bottom either at random or in some sort of nest where they may be carefully guarded, sometimes

even in the mouth, and in all these cases the eggs are usually less numerous, opaque and of larger size. Those laid in nests are often very large and the newly hatched fish are much better able to take care of themselves when they leave the nest than are those that breed by the pelagic method.

It was assumed that *Astroscopus* would be a nest breeder of some kind simply because several of its near relatives, as the toad fish (*Opsanus*) and the midshipman (*Porichthys*) and some others, all lay a very few very large eggs in nests under stones and carefully protect their young until of considerable size.

But when these ten or twelve inch stargazers caught in the summer from lower Chesapeake Bay were examined microscopically under the high-powered lenses as to their ovaries, it was found that all the eggs were so small and so immature that nothing at all could be decided as to their breeding habits.

Such fish were then examined when caught during the time from April to November with the same result, and it seemed that the warmer months were not the months when they bred as most of our Atlantic shore fishes do. It seemed probable that they must breed in the winter months.

So for several years expeditions were undertaken from December to March and the fish were sought in their usual haunts but none was captured. They were dredged for in the shifting sands of half-moon shoals and even in the bay mud where eels and the blue crabs bury and spend the winter, but none were found. The only information obtained was that late in the fall young *Astroscopus* from two and one half to four inches long appeared sometimes in the bay in small schools of several dozen but that even these disappeared in the winter. Did they and the large fish we had been getting dig so deep in sand or mud that we could not reach them or (a new idea) did they go out to sea?

The writer then learned that some fishermen had set several pound nets on the outer shore of the coast at Virginia beach and that one of these nets was several miles out from shore. He visited their fishing camp and after talking with them left some large cans full of preserving fluids (alcohol and formalin) with the promise of reward if stargazers were secured.

The next step to success was secured in this way. In latter May these fishermen found in their traps far larger *Astroscopus* than the writer had ever seen before, weighing fifteen or twenty pounds and measuring as much as twenty-two inches in length, and, best of all, upon dissection it was found that the ovaries were bursting with fully matured and ripe eggs ready to be laid. The eggs were small and transparent and possessed oil globules and it was certain that this fish bred by the pelagic method and that they bred in late spring and early summer. It was also realized that the ten or twelve inch fish in the bay were as yet sexually immature, a very unusual condition, as most fish breed when comparatively young and small.

So the next step was to find the young fish and eggs on the surface of the sea and study the development of their electric organ. The aid of the fisheries experts of the U. S. Fish Commission was sought and one of them brought in, preserved, and sent to Princeton five of the first larval *Astroscopus* that the writer had seen. They were but recently hatched, about four millimeters long and at a stage of development when most pelagic breeding fish leave the surface and go to the bottom if their parents live there as *Astroscopus* does.

Sections were cut and the larval heads were reconstructed in wax and studied

and the disappointment endured of finding that they possessed no electric organ at all or hardly a trace of one. All the eye muscles were present in their proper places and innervated by the nerves that commonly innervate them in fishes and other vertebrates. It even was doubted if these were *Astroscopus* larvae at all but possibly were the young of some other near relative of this fish, as *Kathetostoma*. The muscle fibers in the edges of several eye muscles stained a little darker in color than in others, but this hardly seemed to mean the development of an electric organ.

In August of the next year the Fish Commission steamer *Fish Hawk* was surface towing again some twenty miles off the coast and farther south when her naturalist, Dr. W. W. Welsh, found in the tow and sent to the writer some more larvae of *Astroscopus* of larger size, one of which was nine and one half millimeters long and another fourteen millimeters in length. These were likewise studied, and at last some first trace of the origin of the electric organ was discovered.

The upper edges of the four uppermost eye muscles were seen to be slightly enlarged and to stain somewhat differently from the regular muscle substance. The hypertrophied muscle fibers on the edges of the muscles showed a shortening and widening of one end, another evidence that they *might be* turning into electroplaxes. One still puzzling circumstance was that the superior oblique and external rectus eye muscles were still supplied with nerve fibers by the fourth and sixth nerves exclusively, while the adult electric organ was known to be supplied only by the third nerve. How, then, could we state that the muscle tissues of these two eye muscles played any part in the formation of the matured electric organ? Only an examination of an older stage of the development could show.

Study was then made of some means for securing that older stage, and the writer went to the fisheries laboratory at Beaufort, N. C., to spend the summer and try to get this material. In the first place he now knew that the young *Astroscopus* live on the surface for a

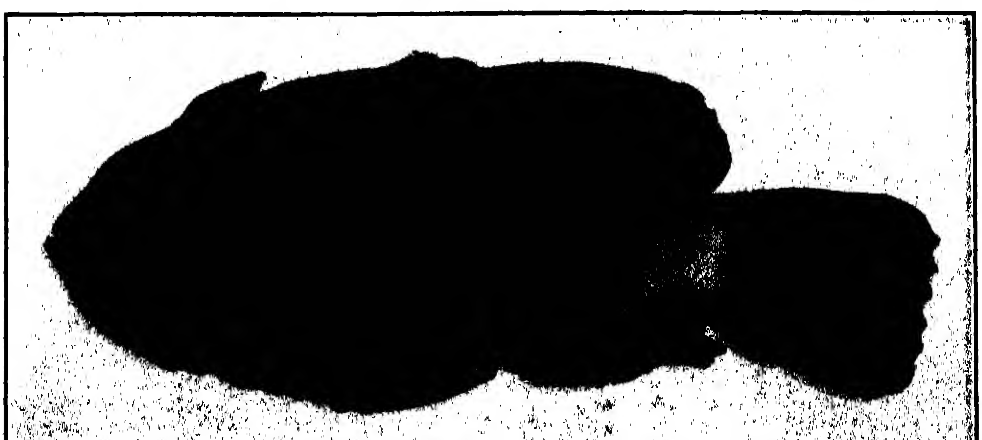


FIG. 8. PHOTOGRAPH OF A PRESERVED TWENTY-MILLIMETER LARVA OF *ASTROSCOPUS*

TAKEN ON THE SURFACE WITH A TOW NET BY THE U. S. F. C. STEAMER *Fish Hawk*, ABOUT FIFTY MILES OFF THE VIRGINIA CAPES.

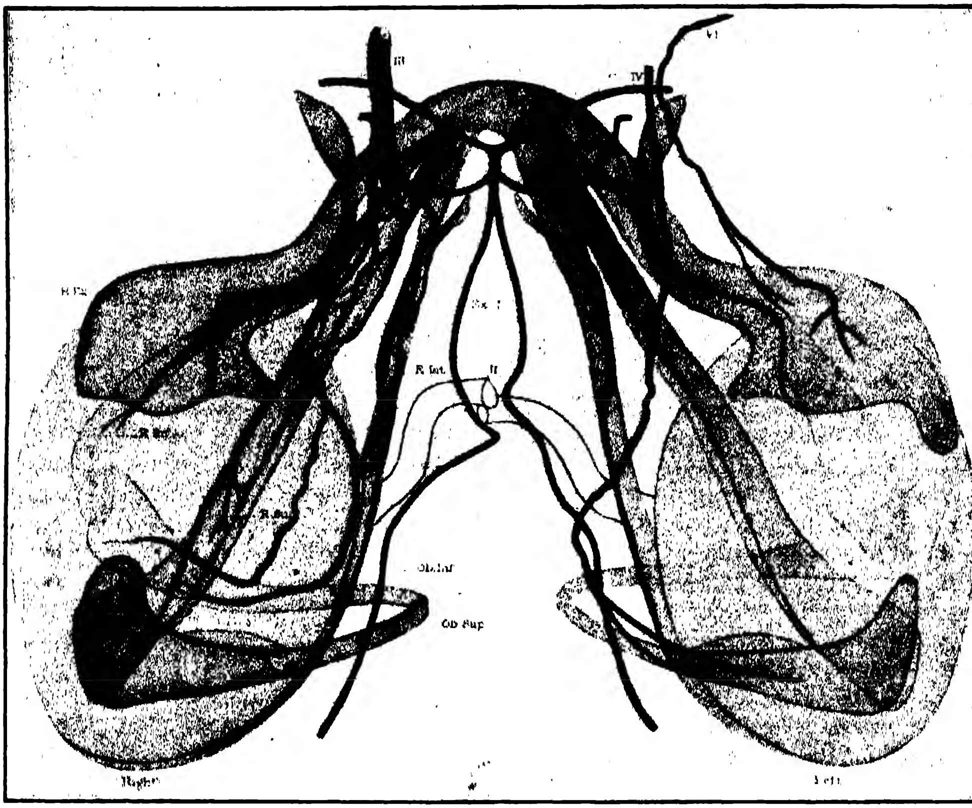


FIG. 9. THE EYES OF *ASTROSCOPUS*

DRAWING OF THE EYES, THE SIX EYE MUSCLES, THE FOUR PORTIONS OF EACH ELECTRIC ORGAN AND THE ASSOCIATED NERVES AND BLOOD VESSELS OF A TWENTY-MILLIMETER *Astroscopus*. THE NUMBERS INDICATE THE NERVES SHOWN, THE INITIALS THE SIX EYE MUSCLES. ONLY THE FOURTH AND SIXTH NERVES ARE SHOWN ON THE LEFT SIDE, AND ONLY THE THIRD NERVE WITH ITS BRANCHES ON THE RIGHT SIDE. THE FEW BLOOD VESSELS SHOWN ARE NOT MARKED. EYE MUSCLES ARE COLORED A SMOOTH GREY TONE, ELECTRIC ORGAN RUDIMENTS ARE STIPPLED. DRAWN BY MISS GRACE WHITE.

much longer time and until a much more complete stage of development than the large majority of pelagic breeders of the fish tribe. This is not so remarkable, as it was known that the file fish, the lump fish, and several others remain at the surface until over an inch or two long, after which they live near the bottom, while some of the flounders, typical bottom fish and pelagic breeders remain at the surface until nearly three fourths of an inch long, so it was possible that *Astroscopus* attains his full development as to electric organ while still on the surface.

The point was, how to get some stages of larval *Astroscopus* larger than fifteen mm. A great deal of towing did not seem to find them. The idea was conceived that the young fish of fortunate

size might be captured on their way down to the bottom by deep towing, but that method failed; so the apparently desperate method was conceived of examining the stomach contents of some kind of voracious fish that lives near but not on the bottom and at once the sea bass, *Serranus*, was thought of. These fish, averaging about two pounds in weight, live in immense numbers near the bottom on some banks a few miles off shore. They are constantly on the alert and hungry for all small diving creatures and it was decided to systematically examine their stomach contents for a considerable period in the hope of getting the desired stage of *Astroscopus*.

This decision was taken the more readily since it was known that many small fishing vessels make a business of catching sea bass in large numbers and dressing them for the market on the grounds. The writer shipped on the cruises of several of these vessels and also went on one trip on the U. S. F. C. *Fish Hawk* off the Carolina coast, and found the fishermen very glad to have some one along who would dress fish for them as fast as caught, although they had grave suspicion of the practicability of his methods or the usefulness of his purpose, even when fully explained.

On a somewhat rough estimate the stomachs of between twenty-five hundred and three thousand sea bass were opened and examined before the first *Astroscopus* was found, and only two were found in all. But these two small fish, one of nearly one inch in length and the other slightly over an inch, were the critical stages sought and told the whole story; especially as Mr. Welsh also contributed another specimen of a little less than one inch (twenty millimeters, Fig. 8) in length, which he had caught in the tow at the surface. The two specimens taken from the sea bass stomach were in an excellent state of preservation for sectioning and histological study, for the first stages of digestion, hopeless as they may appear on first sight, constitute an excellent fixation for the tissues for histological study, and the staining reactions of such tissues are good.

The whole lot of material was turned over to a pupil of the writer, Miss Grace White, who wrote her thesis for the doctor's degree and published the work in the Carnegie Institution Series. Her findings in brief are as follows.

The young *Astroscopus* develops as any other pelagic fish would, while living at the surface of the sea, until over twelve millimeters long. At this time the upper edges of the four uppermost eye muscles begin to thicken and at about twenty millimeters in length these thickened edges begin to separate from the muscle and mass themselves into a group that later constitutes the electric organ (Fig. 9). Those portions that come from the rectus externus and superior oblique eye muscles lose their connections with the sixth and fourth nerves, and branches of the third nerve, which already innervates the other two electric elements, grow out and supply them. Meanwhile all the muscle fibers in all four detached elements of the future electric organ grow shorter and wider until they form flat plates, the electroplaxes.

The electroplaxes have meanwhile grouped themselves into horizontal layers, about twenty in each layer, the layers all lying horizontal in the mass and most accurately spaced apart, with the electric surface up and the papillated nutritive surface down, so that the electromotive force produced by such is added to that of its upper and lower neighbors, in this way producing the sum of about fifty volts during the synchronous discharge of the elements.

Thus we find this remarkable adaptation to sand life, an electric organ on the

FIG. 10. AN *ASTROSCOPUS* RISING FROM ITS HIDING PLACE IN THE SAND TO CAPTURE A SMALL FISH. DRAWN BY R. BRUCE HORSFALL FROM DESCRIPTIONS BY THE WRITER.

top of the head where it is ready to be discharged when any other creature threatens it from above as it lies buried in the sand. It is also possible that it sometimes uses the organ to stun its prey, which consists of small fish that swim over its hiding place, as is done by the larger electric torpedo with his stronger electric organ. It has no need for this, however, as *Astroscopus* can spring from his hiding place and, rising swiftly, capture such fish, as the writer has seen him to both in the aquarium and in nature (see Fig. 10).

We are now in a position to outline the fish's life history in some of its major aspects.

Its egg is laid in late spring and early summer off our sandy coast in water from thirty to possibly two hundred feet in depth. The egg rises slowly to the surface where it floats and hatches into a little transparent fish only a few millimeters long. It grows rapidly, living on its yolk sac, and when about six or seven millimeters long it begins to eat other and younger fish larvae, very often other *Astroscopus*. It then acquires a black color, which deepens with time, and, later, a bright yellow spot appears on its blunt chin. When about twelve or fifteen millimeters long and probably a month old the remarkable change in its eye muscles begins that results in

an electric organ. At about one inch in length, or a trifle over, it begins to swim deeper and finally swims straight down to find the home it instinctively craves, in the sand. I have often thought of the dangers of this final dive. If it reaches a fine sandy bottom, well and good, but if it comes down on a rocky reef there must be many enemies waiting to receive and eat it. And what happens if it settles on a soft mud? The adult fish dislike mud and avoid it.

The young fish when it settles is a perfect young stargazer in form, with its electric organ almost completely developed and its skin much darker in color than the adult. It is now about two to two and one half months old, and its tendency is to work inshore and seek the mouths of our sandy bays, from Long Island to Florida and the Gulf of Mexico. Great South Bay, Barnegat Bay, Delaware Bay, the Carolina sounds are the places that it likes and it shows

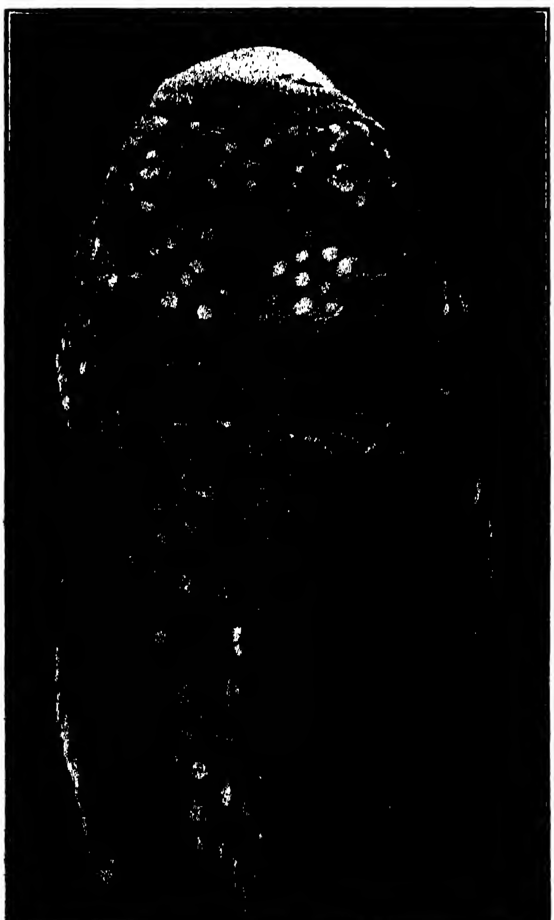


FIG. 11. TOP VIEW OF MOST OF A LARGE SPOTTED *ASTROSCOPUS Y-GRAECUM* FROM GEORGIA, FOURTEEN INCHES LONG. PHOTOGRAPHED FROM A PRESERVED SPECIMEN.

at this age an apparent desire to travel in small schools. When winter comes it probably moves off shore to avoid the severe cold and moves into the bays again the next spring and summer. We have little or no information on this point and in its southern range such short migration is not necessary.

When about eight inches long the fish spends its summers around the mouths of the bays and in their lower wider reaches of water, always staying on the sand and usually bedding in the sand by day and moving about by night. It is also found near shore on the open sandy coast. In the fall, at least in our northern states, it collects at the mouths of the bays and is especially active as cool weather comes on and may often be seen or caught up near the beaches in only a few inches of water. Then, after some cold northwest wind, it is seen no more until spring. We do not know, but it is very probable indeed that it moves off into deep water for the winter. This life, which may be called its bay life, lasts for several years until the fish becomes over twelve or thirteen inches in length and probably from four to six years old. Then it is never seen in the bays again but moves to the sand bottoms some distance off the coast, where it lives permanently, possibly migrating further out in winter and inshore in summer. Now for the first time the ovaries and spermaries, which up to this time have been unproductive in spite of the fish's comparatively large size, mature a crop of ripe eggs and sperm in the early spring of each year, and the fish breed around May or June in the latitude of Norfolk, Virginia. In Florida they breed in January.

Three species of this genus are recorded in the books on fish taxonomy: *Astroscopus guttatus*, found from Long Island, N. Y., to Cape Hatteras, Va.; *Astroscopus Y-graecum* (Fig. 11), found from Hatteras south into Florida and the Gulf of Mexico; and *Astroscopus zepherus*, found on the Pacific shores of the Isthmus of Panama up into the Gulf of California.

In structure all three species are so much alike that very close study is necessary to distinguish between them. This is particularly true of the two Atlantic species. Where they overlap in the neighborhood of Cape Hatteras it seems practically certain that they interbreed, and great variation is found. A prominent external feature of *guttatus* is the large number of white spots set closely together. In *Y-graecum* the spots are larger and less numerous, the size of these marks increasing the further south it lives. Just north of Hatteras many individuals were found in which the spotting characters of the skin conflicted with some of the structural features.

The genus *Kathetostoma* of the same family represents a type from which *Astroscopus* as well as some others of the family *Uranoscopidae* undoubtedly are descended. *Kathetostoma* is much like the young of *Astroscopus* in that while it has the same form and even the spotted back, it has longer spines projecting from the posterior angles of its head, a primitive character according to Dr. D. S. Jordan and other systematists. The species of this genus are found in deeper water in many warm seas.

The family *Uranoscopidae*, of which *Astroscopus* is a member, consists of eight genera and twenty-five species. Most of them resemble *Astroscopus* strongly in general appearance, and *Uranoscopus scaber* from the Mediterranean Sea looks so much like it that it can safely be used as a sample and shown to fishermen when making inquiries as to *Astroscopus*. All twenty-five of these species are found in warm waters with few exceptions and all prefer the sand and show an adaptation to

it. No other genus, however, as far as we know, has gone to the length of developing an electric organ as far as the writer has been able to examine them.

In the next, and a closely allied family, the *Batrachoididae,* we find fishes some of which also closely resemble the unusual form of *Astroscopus,* as the genus *Porichthys* and the genus *Opsanus. Porichthys* has also made much progress in the direction of high and unusual specialization in an entirely different direction, however. It has developed a multitude of tiny light-producing organs on its ventral surface. This is not so unusual, however, as the electric organ, since over five hundred other species of fish and many hundreds of other animals in all the animal phyla have done the same.

The above is a brief account of the history of one very interesting fish. Many gaps, some not noticeable to the reader and some not known to the writer, still exist in the account. Thousands of other form have histories that will well repay, in interest and in usefulness, careful study and observation, to the naturalist as well as to the more casual observer. Many have been thus studied. Let us hope that some of these studies will be made complete.

CHEMICAL MICROSCOPY—TIME AND LABOR SAVER

By Professor E. M. CHAMOT

CORNELL UNIVERSITY

THE slogan of the day—"Bigger and Better Business"—is finding an echo in shops and laboratories where it is being paraphrased into—"Quicker and Better Service." As a result, fewer useless routine tests and analyses are being made, less valuable time is wasted and more easily interpretable data are being obtained and submitted for consideration and study. This does not mean that fewer tests and analyses are called for, far from it, but it does mean that the technician is exercising better judgment in his efforts to throw light upon some definite phase of a given problem.

It has thus come about that there are few chemists to-day who accept a sample for analysis without further information than "analyze this for me and let me have the results as soon as possible." Before he begins his work, he asks, "Why is an analysis wanted? Just what do you wish to learn concerning this substance, and what reasons have you for believing that it is a chemical analysis that will throw light upon or solve your problem?" These questions arise whether the chemist is a public analyst or whether he is one of the technical staff of a large corporation: in the latter case is it especially true.

The cost of reagents, apparatus and instruments has markedly advanced in recent years; while time and labor have greatly increased in value, at least as measured in terms of speed and in dollars. Furthermore, the "overhead" in all laboratories has reached figures which necessitate a reduction of as much as possible of useless routine analyses.

Here is where the intelligent and judicious use of the microscope has come into play—chemical microscopy—an art which to-day enables the analyst to solve a large proportion of his problems, with a minimum expenditure of energy, time and material. Thus it follows that the returns on the capital invested in this type of laboratory equipment may prove to be relatively much greater than that invested in what we may call the customary equipment of the laboratory.

The purpose of this article is to endeavor to make these points clear and to convince the skeptical that microscopic methods are becoming well established in the chemists' laboratories and that although their advantages were long overlooked their use has become widespread and their value fully recognized.

Microscopic examinations are not being adopted for the purpose of displacing standard chemical analyses but for supplementing them or because information may often be thus obtained which renders chemical analyses superfluous. The following case may be cited as a typical example. An archeologist brought to a chemist the beautiful coin shown in Fig. 1. "Here is an exceptionally fine Greek tetradrachm that has been offered to a collector at a remarkably low price. He brought it to me to have me pass upon its genuineness. I suspect it to be a very clever forgery. It has not the normal weight of a tetradrachm nor does it feel quite right. Take a 'streak-sample' and make a micro-chemical analysis and see whether it is silver or not." "Suppose we look at the coin first under the microscope,"

answered the chemist. "Perhaps it may not be necessary to have recourse to an analysis." Suiting the action to the word, he took one glance; then, turning to his friend, exclaimed, "You are quite right in your suspicion; the coin is spurious. Look, you can see for yourself that the coin has been cast, not struck, for the surface shows well-formed dentritic crystals, with no evidence of having been 'worked,' as would be the case had the coin been struck [see Fig. 2]. Moreover, the crystallization is such as to preclude its being silver, for silver does not give dendrites with this habit. There is little doubt that we have here a base-metal alloy, probably one in which tin predominates."

Thus by a simple microscopic examination the chemist was able to solve the problem put to him by the archeologist. It required only a few minutes, affected the coin in no way and required the expenditure of no reagents. It should be quite obvious that microscopy was, in this instance, both a time and labor saver. But, the reader will say, an analysis of the coin was not really necessary, since its weight and "feel" pointed to the fact that it was spurious. All of which the writer admits, but the reader must remember that the archeologist had called for a chemical analysis so as to learn whether the coin was made of silver or of a base-metal alloy in order to settle the question as to its abnormal weight and "feel," and that he was given this information through a microscopic examination alone; an examination which required a mere glance at the magnified image.

Lest this case of the tetradrachm should be believed to be unique it can be asserted that there is a growing tendency in the industries to-day to submit at once to microscopic examination all metals and alloys which have proved defective or abnormal or whose compositions are in question. It is not so many

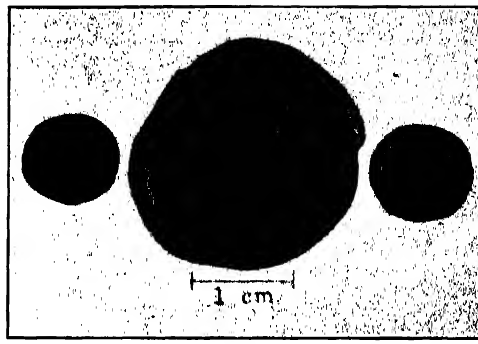


Fig. 1. Modern counterfeits of ancient coins.

Fig. 2. Highly magnified surface of the central coin in Fig. 1.

years ago that in all such cases a complete chemical analysis would have first been called for as a matter of routine, under the belief that the abnormalities must be the result of peculiar chemical compositions. These analyses were often difficult and were time-consuming and expensive. Not infrequently upon their completion little or no light was thrown upon the problem at issue. Physical chemistry, the microscope and the pyrometer have revolutionized our ideas with the result that much time, labor and worry are saved by having recourse to routine chemical analyses only after

a microscopic examination has failed to completely solve the riddle. In the magnified image of a properly prepared alloy the expert is able to read a wondrous story.

But it is not only in the metallurgical industries that chemical analysis may prove to be unnecessary. It is now well recognized that the commercial success or failure of many products may depend largely upon the results of judicious microscopic studies of raw materials as well as of finished or partly finished products. These may be as far apart as milady's silk hose and the earth of a road to be surfaced with tar; or a "baby powder" and the pigment or filler entering into a rubber tire; or ore to be subjected to flotation and rosin for "size"; or a detergent or polishing powder and an abrasive wheel. Each and all, and a thousand and one more are being examined, studied and tested microscopically in order that qualities may be improved, production cheapened and sales increased.

Unfortunately, not all our firms have as yet come to realize the importance of these comparatively new methods, for example: a plant working a rock salt vein by forcing down water and pumping up the brine obtains a brine containing much calcium sulphate (gypsum). It was their custom to remove the calcium salt by adding a chemical which would precipitate it. There came a time when having lost their records and having no knowledge of the proper dosage they prepared a batch of salt and submitted a sample to a young chemist with the request that he determine whether or not all the gypsum had been removed and whether the product could be placed on the market as table salt. The chemist attacked the problem in the old orthodox manner: he determined the amount of chlorin, which he then calculated as sodium chlorid, the amount of calcium, which he calculated as calcium sulphate; the amount of sulphate ion, which he also calculated as calcium sulphate. But the two values he obtained for calcium sulphate did not agree. Puzzled, he consulted a more experienced fellow chemist, who remarked: "Before going over your figures let us see what the microscope will reveal.—— Look, my friend! Your sample must contain, I guess, not far from forty per cent. of gypsum." A photo-micrograph of this identical sample is shown in Fig. 3. The cubes and cubical masses are crystals of sodium chloride (common salt), the prisms and plates are the crystals of calcium sulphate (gypsum). A single glance through the microscope showed that the dosage had been insufficient and also enabled the observer to form an idea as to the quantity of impurity still present. This particular case is cited because it illustrates another advantage of microscopic methods, namely, that the process need not have been carried to completion and the salt separated from the brine. A small sample taken out during a run would have given in a few seconds all the information necessary. This is by no means an isolated case, but

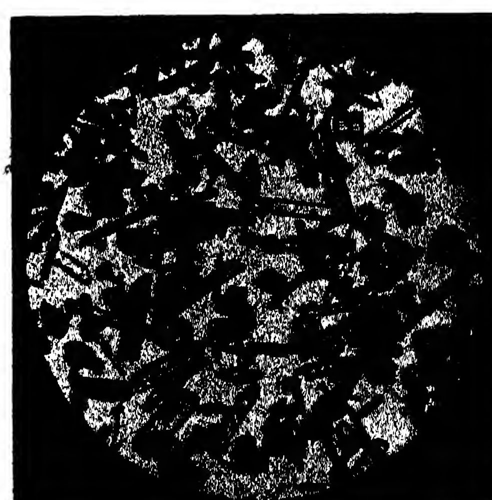


FIG. 3. SAMPLE OF COMMON SALT CONTAINING GYPSUM.

is typical of what is being done more and more in the control of many diverse processes especially where a time factor enters or where it is desired to closely follow the progress of a reaction. In all such cases it suffices to remove small samples from time to time and submit them to microscopic examination. Where such methods are adopted instead of long solubility determinations or complicated analyses, the saving in time, labor and material may be relatively very great.

This does not mean that microscopic examinations are destined to displace or supplant the older, well-established, time-tried chemical control methods in the industries. Microscopic tests and estimates are often, at best, merely clever guesses. Yet they may be, with care, so very close to the truth that where an estimate only is needed and not an exact determination, it would be the height of folly for the analyst to overlook the economic possibilities of chemical microscopy.

Not infrequently a microscopic examination has shown at once that a preconceived hypothesis was completely wrong: a hypothesis that had been built up to explain phenomena or to account for low yields or for defects in manufactured articles. Here is a case in point. A run of smokeless powder was found on analysis to be too high in its ash content to pass inspection. The technical men of the powder plant built up a number of ingenious but wholly untenable hypotheses to account for the trouble. Much valuable time and money was spent in trying to uphold preposterous explanations which were contrary to common sense and mathematics. Had the powder-ash been examined under the microscope at once instead of after many days of fruitless discussion it would have been seen that the excessive ash was due to fine silt from dirty, improperly cleaned cotton. Of course, the trouble all started in bad sampling of the raw cotton and since the chemist's figures were wrong no one was convinced until the microscope revealed the true nature of the ash. In Fig. 4 we have a photograph of the ash of this rejected powder. The silt grains S, S, are easily differentiated from the normal ash P, P, of the pyroxylin. Were further confirmation deemed necessary the absolute identity of the minerals in this ash with those of the soil clinging to the cotton could very easily be proved, nay more the identity of the silt in the ash with that in the cotton field where the cotton was grown could also be established.

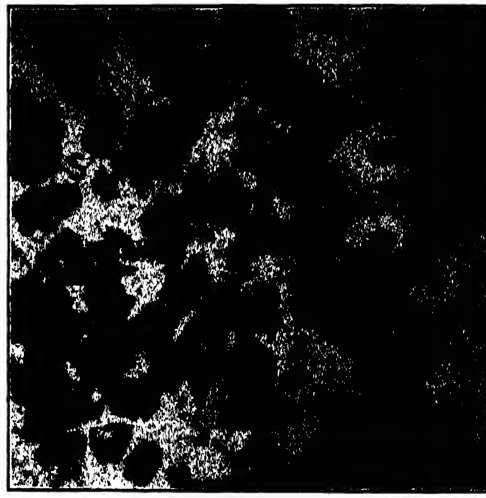


Fig. 4. Ash of a pyroxyline powder containing silt.

Let us now consider a very different sort of problem. The customers of a certain firm were approached by a representative of a competitor and told that the preparation which he would supply them for a certain purpose consisted of a single organic compound, while that which they had been buying consisted as they knew of two different compounds. Since his preparation had only one ingredient it stood to reason that its uniformity could be depended upon; but with two components, well! they could draw their own conclusions:

prices could be made right. The chemist of the firm originating the preparation surmised that the alleged single ingredient material was identical with theirs and in reality contained two compounds. Since the two compounds were very closely related substances and their identification in a mixture would be difficult indeed, he concluded that time and labor might be saved by having recourse to microscopic methods. He therefore laid his problem before a microscopist, who at once pointed out that the refractive indices of the crystals of the two compounds were widely different, no matter in what position the crystals might chance to lie; hence by selecting a liquid having the same index of refraction as one of the compounds and covering the preparation in question with this liquid, that particular compound would be practically invisible under the microscope while the other compound would stand out sharply and clearly. Not only could the two be thus easily differentiated, but the relative proportions of the two compounds in the mixture could be estimated without resorting to long and difficult analytical methods. Moreover, these results could be checked by making a second microscopic preparation using in this case a liquid having an index of refraction equal to that of the compound which had not been rendered invisible in the first experiment; under these conditions the second component of the mixture would become invisible while the first would be clearly defined and its amount readily estimated. That this procedure proved that the chemist was correct in his surmise the reader can judge for himself by consulting Fig. 5. This photomicrograph shows the material alleged to consist of but a single compound after it had been covered with alphamonobromnaphthalene. It will be seen that there are present crystals which have been rendered practically invisible, which have been marked "A" and that there are also crystals which stand out with well-defined contours, "B." It should be obvious that we have here proof that there are two compounds present and not one only.

FIG. 5. DIFFERENTIATING BETWEEN TWO COMPOUNDS HAVING DIFFERENT REFRACTIVE INDICES.

Space will not permit a discussion of the methods employed for solving the other part of the problem, namely, proving the identity of the compounds in each of the two preparations, the original and the infringing one. Suffice to say that it was quickly and easily accomplished through the determination of the optical constants of the crystals of the compounds. It has taken as long to tell this little story as it does to make the tests and observations.

All these methods are very old and have been employed by mineralogists and petrologists for many years, but only recently has the chemist come to fully appreciate their value in qualitative analysis. By their use he is now able to rapidly ascertain the exact composition of most salts and of a great number of carbon compounds without the necessity of time-consuming quantitative analyses. Because he now employs only tiny amounts of material,

large samples are no longer essential and he has thus been rid, in large part, of his *bête noir*—the gathering of a sufficiently large sample to permit him to perform an analysis by the good old orthodox methods.

It is not possible to prove by photographs or other graphic methods that qualitative analysis by micro-chemical reactions is far more rapid than by the usual macroscopic test-tube reactions. The reader must take my word for it.

Rapidity is gained largely because small quantities are involved under relatively high concentrations, conditions which favor the rapid separation of the crystalline products upon whose formation the identification of compounds depends.

The space required for performing an analysis is very small. In Fig. 6 is shown an object slide upon which was made the analysis of an alloy corresponding in composition to that from which the coin shown in Fig. 1 was probably cast. A tiny fragment the size of the head of a small pin was dissolved and tested at "a," the supernatant liquid was decanted to "d" divided into several small drops, which were all

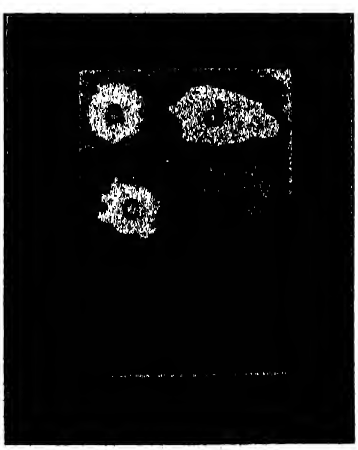


FIG. 6. A COMPLETE QUALITATIVE ANALYSIS PERFORMED UPON AN OBJECT SLIDE WITHIN AN AREA OF ONE SQUARE INCH.

FIG. 7. OBTAINING A SAMPLE FOR ANALYSIS BY THE "STREAK" METHOD.

tested by suitable reagents at "c" and "d." The photograph of the object slide was taken after the completion of the analysis. The alloy was found to consist of tin, bismuth and lead, with traces of copper, zinc and iron. The time required was thirty minutes, the cost of the material used was not over two cents and, as can be seen, the entire analysis was performed upon an area one inch square.

When small pieces or drillings may not be taken from a specimen for analysis, that is, it must not be injured in any way (as, for example, in the case of rare ancient coins, valuable archeological specimens, etc.), recourse is had to streak-sampling which has already been referred to above. This is accomplished by lightly drawing the specimen across the surface of ground-glass, unglazed porcelain or similar hard, slightly rough, material. A minute amount of the specimen is thus removed and clings to the rough surface, from which it can subsequently be removed by means of a suitable solvent. In Fig. 7 such a tiny streak has been magnified in order that it may be clear that such a procedure is in reality equivalent to filing off a sam-

ple and that an ample quantity of material has been obtained upon which to perform an analysis by microscopic methods. Unless a moderate magnification is employed, one can not discover where the specimen has been sampled and even then one can not be sure unless one knows beforehand just the precise spot which touched the abrading surface.

When streak-sampling is impracticable, the analyst removes infinitesimal quantities under the microscope, using for this purpose a variety of different sorts of tiny tools. Yet even in such cases it is impossible to detect where or how the sampling was accomplished. This may be fairly well illustrated by Fig. 8, in which is shown the "reverse" of a gold stater from Lampsacus, whose authenticity was questioned. The microscope showed that it was not a simple casting but had been either struck or hammered. A streak-analysis proved that it was of gold of a quality consistent with an ancient origin. The patina in the depressions in the coin was seen to be abnormal and under moderate magnification had every appearance of having been applied with a brush. An infinitesimal amount was removed under the microscope and on analysis was found to consist of gum, starch, coloring matter (a water color) and a very little fine silt; a very cleverly imitated patina. In the figure the coin is shown, magnified. before and after the removal of sufficient "patina" for the analysis. The removal was made at the spot indicated by the white arrow, "R." Even a careful scrutiny of the two photographs will fail to disclose any evidence of sampling.

The few examples of the efficacy of microscopic methods which have been discussed in this article are each typical of many analogous cases which have been successfully attacked by similar procedures. They have been selected because of their simplicity. Complex qualitative analyses are being dealt with more frequently by more complicated optical-crystallographic methods whenever the chemists have the necessary training and experience.

The proof that these methods are regarded as important and essential is evidenced by the establishment of schools of microscopy and the announcement of one department of chemistry after another in our universities that instruction will be given in micro-chemistry.

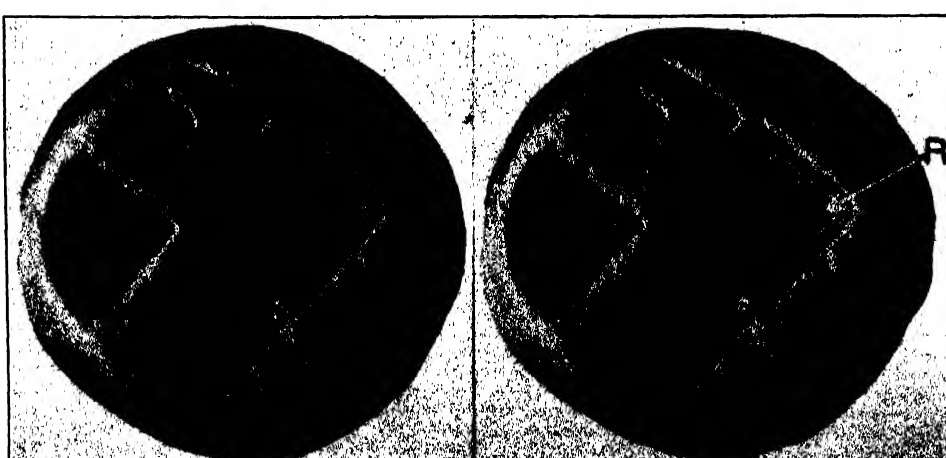
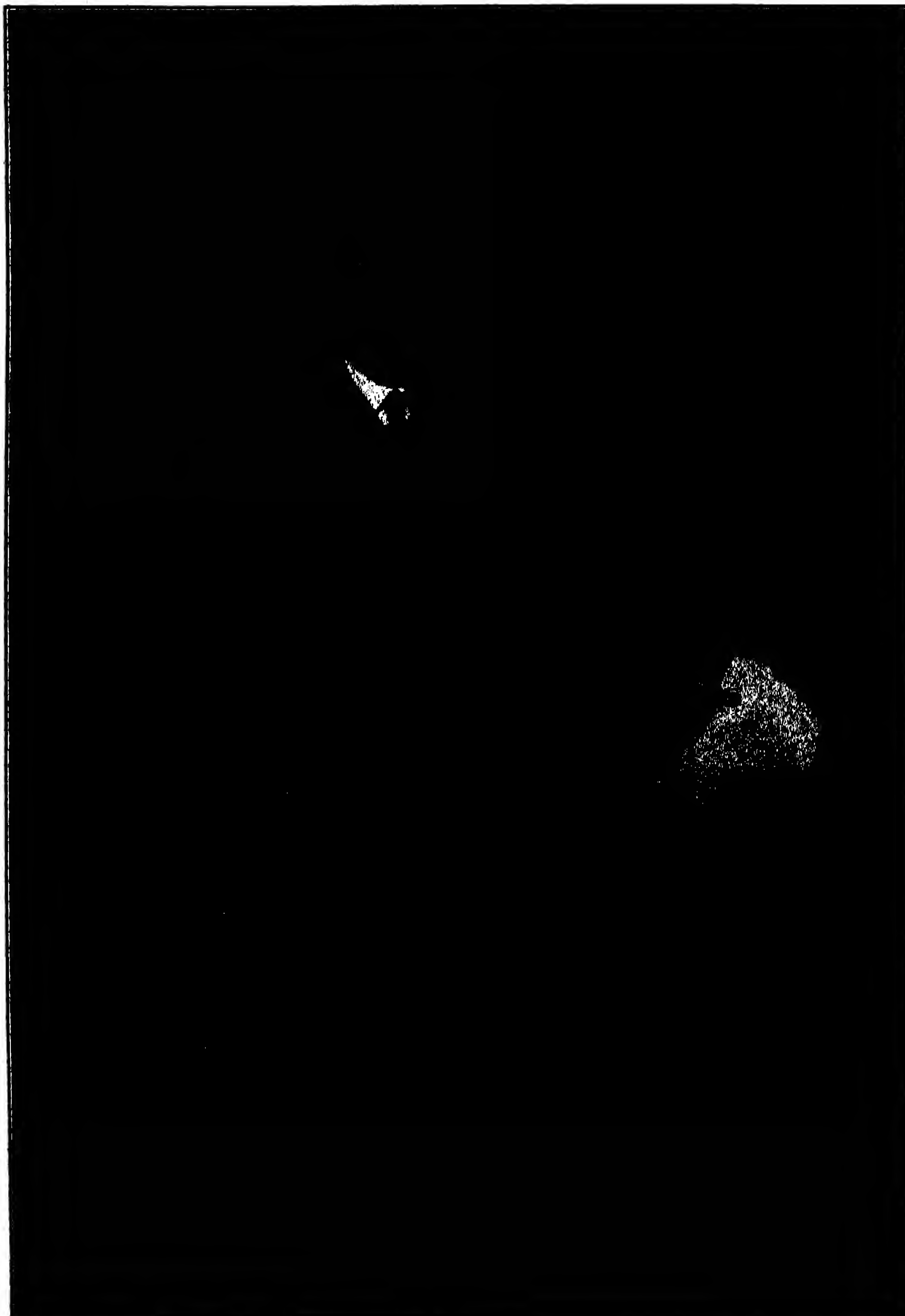


FIG. 8. MODERN COUNTERFEIT OF AN ANCIENT GOLD STATER, BEFORE AND AFTER ANALYSIS.

FIG. 9. LABORATORY OF INTRODUCTORY CHEMICAL MICROSCOPY, DEPARTMENT OF CHEMISTRY, CORNELL UNIVERSITY.

Cornell University was one of the pioneers in this field: as long ago as 1900 courses for undergraduates were offered in microscopic qualitative analysis. From a small laboratory accommodating at first only four students, there has developed the magnificently equipped room shown in Fig. 9, together with three other laboratories devoted to special microscopic investigations. Evidently chemical microscopy, the time and labor saver of the chemist, has come to stay in industrial and in research laboratories, both at home and abroad.



IRA REMSEN

PROFESSOR OF CHEMISTRY IN THE JOHNS HOPKINS UNIVERSITY SINCE ITS FOUNDATION IN 1876 AND SECOND PRESIDENT OF THE UNIVERSITY. THIS PORTRAIT OF DR. REMSEN WAS PAINTED BY HIS SON, AT WHOSE HOME IN CALIFORNIA HE DIED ON MARCH 4.

THE PROGRESS OF SCIENCE

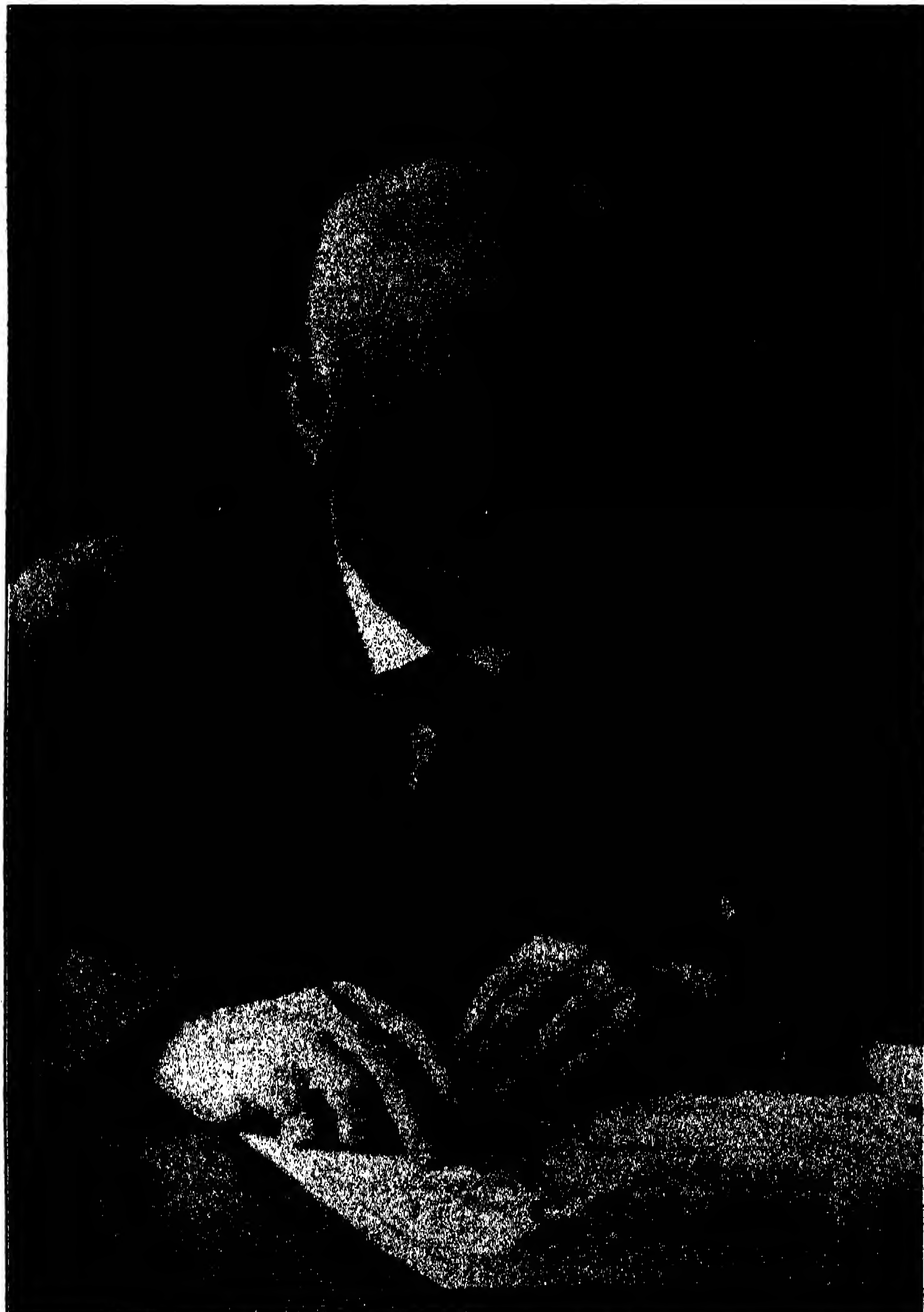
EDITED BY DR. EDWIN E. SLOSSON
Director of Science Service

NATURE'S NOTEBOOK

BY DR. FRANK THONE
Science Service Staff Writer

"CHEER-UP! Cheer-up! Cheer-up!" The most incurable optimist in the world is the robin. He comes shouldering his way through the roughest March wind, proclaiming obstinately that spring is here, and he'll keep on proclaiming it through a whirling snowstorm, or until a hailstone big as the proverbial hen's egg hits him on the head. He hasn't any sense at all, and that's why we like him. You can't convince an American, of course, that a robin isn't a robin; but actually, as a fine point in ornithology, our robin is a thrush. The early English colonists were very fond of the English robin, a smaller bird but with a brighter breast, and belonging to a somewhat different family, and when they settled on this side of the Atlantic they transferred the name to the red-breasted bird they found here, regardless of the fact that when "the north wind doth blow" he does not "hide in a barn to keep himself warm" but migrates southward below the severe frost line. But now our robin is a robin to all of us, and we defy any one to take away his name as he would defy any one to take away his worm. How the robin finds worms under the ground has been a standing riddle to naturalists for generations. He certainly can't see them, and it is hardly likely that he can smell them; yet when he makes the dirt fly furiously for a minute he almost always ends up with a one-sided tug of war with a worm. The best guess seems to be that his ear is so unbelievably keen that he can hear the faint rasping sound an earthworm makes in its burrow. The fact remains that he does get it!

WE are accustomed to treating the skunk as a somewhat shady joke; somehow everything that has to do with the sense of smell seems to be comic to most people; poor Cyrano was the only mortal to whom a nose was not funny. So we run when we see a "woods pussy," and indulge in persiflage about him afterwards. But really, our humor about the skunk is somewhat misplaced. He is himself as serious as a Scotchman, and as thoroughly given to minding his own business and letting other folk mind theirs. Only when he is interfered with does he unlimber his one potent means of defense. That is something not to be used for a trifle, because chemical warfare, whether waged by man or beast, is expensive. It takes a lot of feeding to distil a sacful of mephitic extract. So if you let him alone you are in no danger from him. And if you let him alone he will do you many a good turn without your ever knowing about it. For the skunk, like all the rest of his kin of the weasel tribe, is a tireless hunter of vermin. Rats and mice and such small deer are his principal food, but he does not despise succulent beetles and other good sized insects that prey upon our crops and timber. True, he sometimes forgets his manners so far as to rob a henroost, and frequently also he pounces on our friends the toad and the frog; but the evil that he does is more than outbalanced by the good. Finally, skunks somehow lose their terror when they depart this life—in a hurry and much against their wills—to become furs for milady. Formerly this handsome black-and-white pelt had to be sold under vari-



CHARLES CLEVELAND NUTTING

CURATOR AND PROFESSOR AT THE IOWA STATE UNIVERSITY SINCE 1886, IN WHOSE DEATH ZOOLOGY SUFFERS A SERIOUS LOSS.

ous aliases, but now we have the courage of our desires (if we have the purchasing power to back it), and in coat or neckpiece we are willing to call a skunk a skunk.

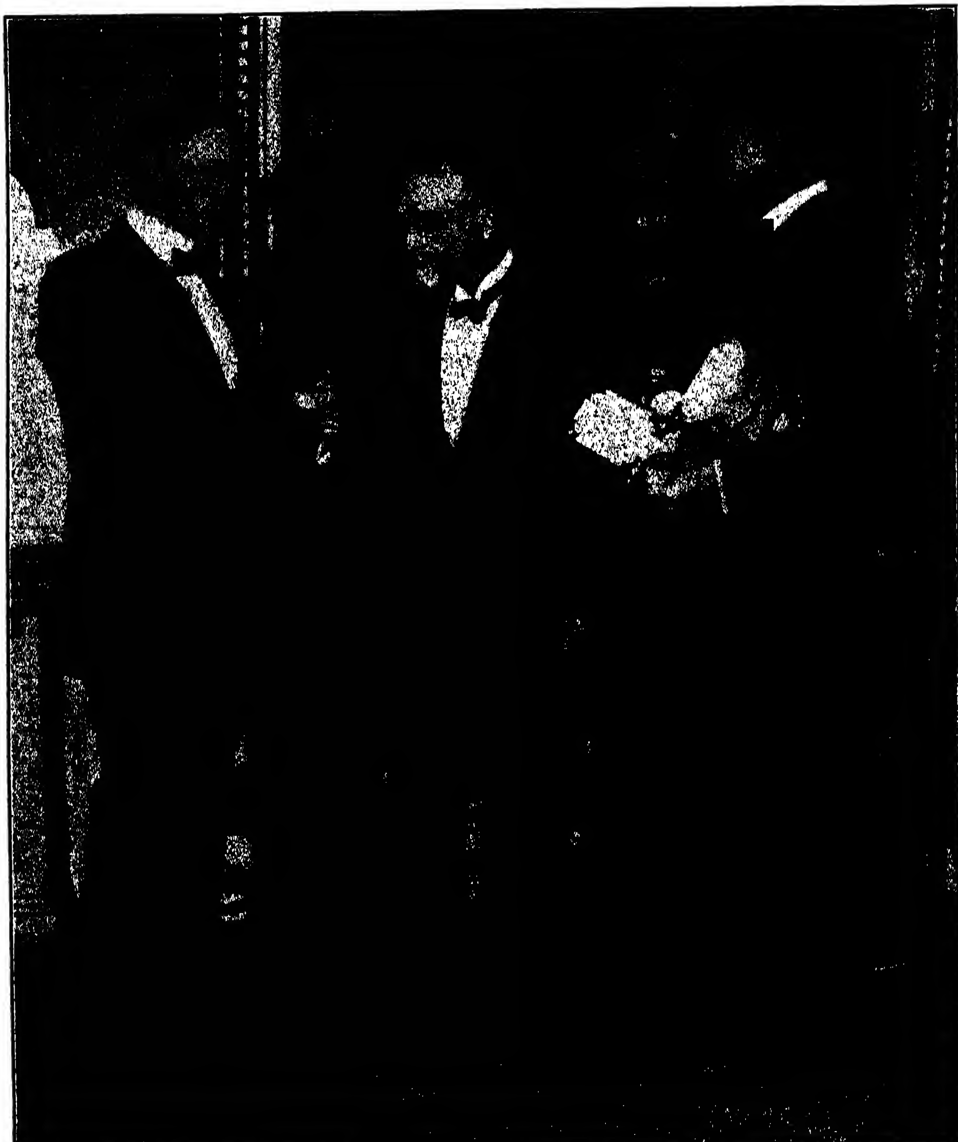
A GENERATION ago, muskrat furs were not held in very high regard; to-day, with the supply of the more precious peltries of the Canadian high north becoming depleted and the Siberian supply seriously interfered with by the effects of political revolution, muskrat has become a valuable staple in the fur market. So much so, indeed, that muskrat "farming" is taking its place among our industries, along with the farming of the highly expensive silver fox and the rigidly protected sealeries of the Pribilof Islands. Muskrat farming, however, partakes more of the nature of protected and systematized trapping on private preserves than it does of the exploitation of fairly well domesticated animals like the fox. The principal commercial muskrat area is in the vast swamps of the Gulf edge of Louisiana, where great private holdings of the almost valueless land (if it can be called land) are parcelled off and leased out or sold to the trappers. These men know from experience how much trapping a given piece will stand without being depleted, and practise conservation of the animals for the benefit of their own business. This profitable fur-raising industry is coming into embarrassing conflict with the program of sanitary engineers working against the mosquito pest in the South. The engineers want to drain the swamps to relieve the cities and the upland farms of the swarms of plaguing, and frequently malaria-bearing, mosquitoes. The muskrat farmers naturally want the swamps left alone, for their living depends on them. A *modus vivendi* between the two interests is now being sought.

THE early bird may get the worm, with our entire approval; but the early fly should get it in the neck. A stitch in time saves nine; a swat in time may save nine million. Now is the time for all good housewives to come to the aid of their country with the fly-swatter. Or if they can not find it, they should hurry to the corner store and get a new one at once. The very first flies, the ones that have survived the winter furtively hiding in odd corners in a semi-dormant condition, are the ones at which the first drive of eradication should be directed. It used to be thought that these were harmless, but the Department of Agriculture now states that they are capable of propagating their evil breed, and therefore should be regarded as enemies. Of course, the swatter is of avail only domestically. The early campaigns for the stopping of the fly pest should hunt for their source of supply, which is almost solely the manure piles of stables, and the drive should not be stopped short of seeing these cleaned up, and all unavoidable litter kept in covered pits or bins and sprayed with kerosene or sprinkled with lime. There is little excuse for fly-breeding places in cities any longer, with the ever-decreasing urban use of horses. On the farm, where livestock is still a prime necessity, their presence may be looked upon as an evil, unavoidable perhaps, but none the less not to be tolerated beyond the most irreductible of minima.

PRETTY pussies down by the brook,
Swinging away to and fro
On the bending willow boughs,
Like pussy cats all in a row!

If I put you down by the fire,
You pussies so cunning and shy,
I wonder if you'd turn
Into pussycats bye and bye?

Who does not remember this old song, which we all learned during March of that memorable first year in school? Even to the keen regret we all experienced—and it lingers in most of us still—that the little gray catkins held loyally to their duties as pussy-cats to the fairy



PRESENTATION TO DR. CHEVALIER JACKSON

PROFESSOR JACKSON, OF THE JEFFERSON MEDICAL COLLEGE, IS RECEIVING FROM SENATOR PEPPER, OF PENNSYLVANIA, THE BOK PHILADELPHIA AWARD FOR PUBLIC SERVICE, CONSISTING OF A GOLD MEDAL AND TEN THOUSAND DOLLARS. THE AWARD WAS MADE FOR DR. JACKSON'S WORK WITH THE BRONCHOSCOPE.

folk? Like many other things that come on very early in the spring, when frosts still come every night and snow may come any week, pussy-willows do seem to belong to another world. In a sense they do belong to another world, even to the cool and factual eye of science. Their season with us is the season of barely melting ice; these strange flowers blossom and shed their pollen and achieve fertility and form their seeds, all before the bees, and the bright-petaled blossoms that depend on the bees, are abroad at all. Willows can thrive and reproduce in a world without insects; the cold wind is duenna enough for their love-making. A world without insects? Well, such a thing obtained, at least locally, fifty or a hundred millenniums ago, along the edges of the ice sheets of the Glacial Epoch. That there were willows there then can hardly be doubted. Willows now push their advance to the edges of the polar ice cap and to the snow line of our high mountains, and willow remains are thick in the bogs left by the retreat of the glaciers. Whatever gnomes or kobolds the days of the Long Cold knew had at least the comfort of little furry tabbies lined on twigs.

Among the very earliest of showy cultivated flowers, almost as early as the pussy-willow and the skunk cabbage, is the crocus. It hardly waits for the snow to melt off the lawn before it pushes its sudden bright blossoms up through the short, crisp green grass. It seems a bit queer to find these big flower-stars scattered about, with never a leaf to account for them. For the leaves mostly come only after the flowers have gone, and look so much like big grass blades themselves that few of us pay much attention to them. The answer is that the flowers do not depend on the leaves. Obviously they can not, for if they did they would constitute a case of the effect preceding the cause. They do depend on leaves, but the leaves are the ones that grew last year, and formed the starchy corm, the thick, onion-shaped storage organ underground that feeds its substance up into the sun-seeking flower. Though commonly called a bulb, this foundation of the crocus is not a bulb in the strict sense of the word, and therefore it gets another name. Onions are true bulbs, and lilies and tulips, which are closely related to onions, also spring from bulbs. If you cut an onion in two you will see that it is formed of layer upon layer of thick, fleshy scales, which are really leaves specially modified to store up food. But the corm of a crocus does not show this layer-arrangement if it is cut. It is solid clear through, and the leaves are represented only by lines or scars on its brown outside. It performs the same service, but its build is different, so it gets a different title.

THE BICENTENNIAL OF NEWTON'S DEATH

The twentieth of March of this year is the two hundredth anniversary of the death of one of the greatest scientific men of all time—Sir Isaac Newton. His long life of eighty-five years comprised many different activities. As a young man he practised alchemy. He wrote many theological treatises; he was a professor at the University of Cambridge, and for the last thirty years of his life he was the master of the British Mint. But upon none of these does his fame rest. Hundreds of men have equalled or exceeded Newton in such respects, and all have been swept by relentless time into the limbo of mediocrities.

Why is Newton remembered? Not primarily for his experimental work in optics, important as this is, for a dozen others have done as well. Not because

SIR ISAAC NEWTON

he "discovered gravitation"; that had been known since the days of Aristotle. Not because he formulated the exact law according to which gravitation acts, for that appears to have suggested itself to at least three of his contemporaries. Not that he was the first to conceive the idea that the earth's gravitative attraction might reach as far as the moon; that had been imagined before him, though no demonstration of it had been given.

Newton stood head and shoulders above his contemporaries because he had vision, a broad mental grasp, a good sense of perspective. Scientific knowledge before his day consisted chiefly of isolated facts of observation, with little or no correlation, and no satisfactory assigned causes. But Newton was able to visualize all the moving bodies in the universe from comets to falling apples, and to demonstrate that they all obeyed a single law—universal gravitation. He brought order out of chaos; he had constructive talent; he was a builder, not only a collector of building materials. It was nearly two hundred years after the publication of the "Principia" before the scientific world saw its like, until Darwin, with the "Origin of Species,"

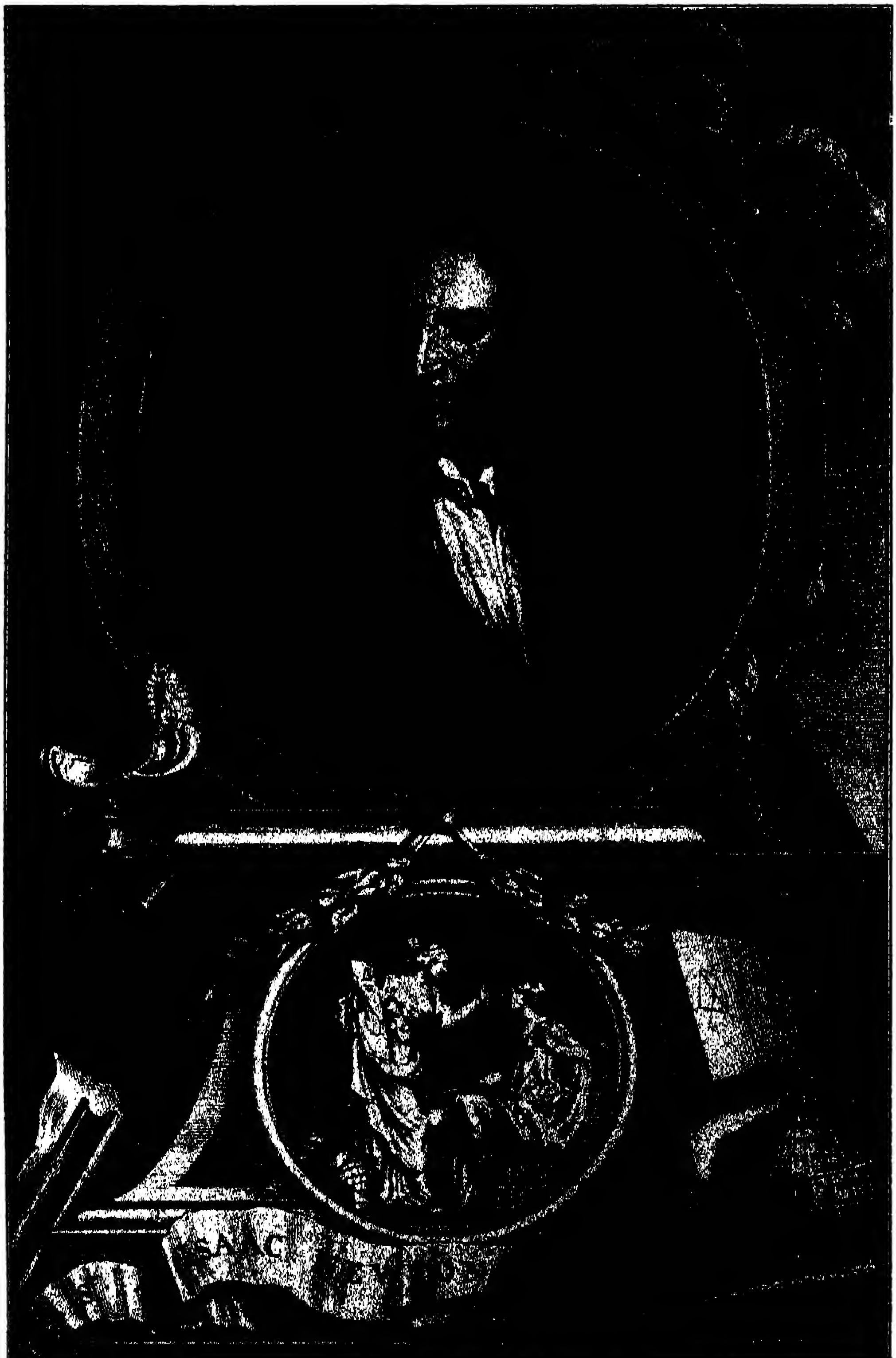
WOOLSTHORP MANOR HOUSE, THE BIRTHPLACE OF ISAAC NEWTON

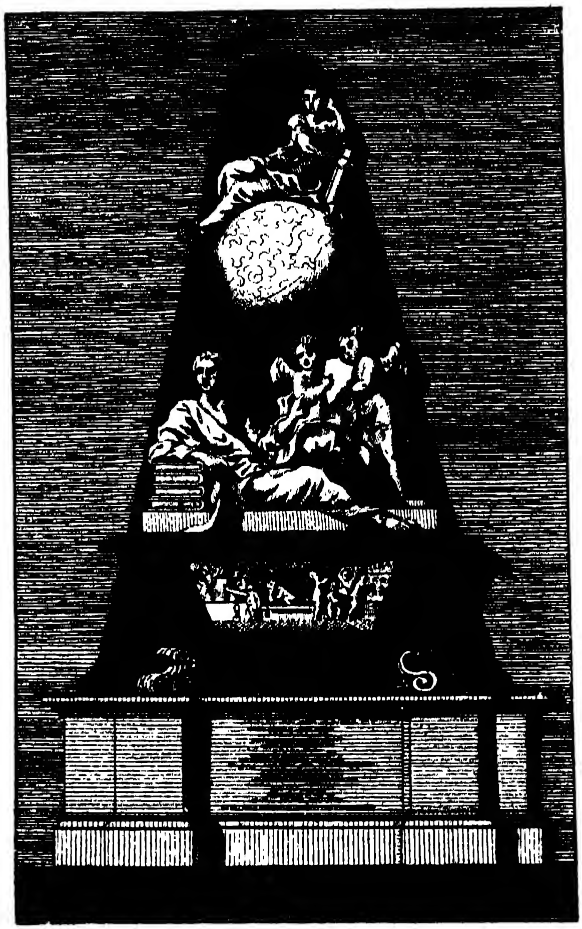
THE RESIDENCE OF NEWTON
ST. MARTIN'S STREET, LEICESTER FIELD, LONDON

did for biological science what Newton had done for physical science two centuries earlier. Such men are rare, but scientific progress would be impossible without them.

How thoroughly Newton accomplished this task is evidenced by the change in scientific thought since his day. The "Principia" is taken for granted; the picture of the universe set forth in it is part of our common heritage, almost innate. Newton succeeded in endowing all scientific posterity with a measure of that vision and perspective which he alone possessed in his day. He said modestly of himself: "If I saw farther, 'twas because I stood on giant shoulders." But by the hands of Newton we have been lifted and placed upon a peak which he himself could not reach, from which, like Moses of old, we may look over the Promised Land, though it may be reserved for those who follow us to enter.

This appreciation of Newton's great constructive contribution to modern science has been prepared by Dr. Paul R. Heyl, of the U. S. Bureau of Standards. For most people Newton's name is iden-





INSCRIPTION ON NEWTON'S TOMB IN WESTMINSTER ABBEY

HERE LIES
SIR ISAAC NEWTON, KNIGHT,
WHO BY A VIGOR OF MIND, ALMOST SUPERNATURAL,
FIRST DEMONSTRATED
THE MOTIONS AND FIGURES OF THE PLANETS,
THE PATHS OF THE COMETS, AND THE TIDES OF THE OCEAN.
HE DILIGENTLY INVESTIGATED
THE DIFFERENT REFRANGIBILITIES OF THE RAYS OF LIGHT
AND THE PROPERTIES OF THE COLORS TO WHICH THEY GIVE RISE.
AN ASSIDUOUS, SAGACIOUS, AND FAITHFUL INTERPRETER
OF NATURE, ANTIQUITY, AND THE HOLY SCRIPTURES,
HE ASSERTED IN HIS PHILOSOPHY THE MAJESTY OF GOD.
AND EXHIBITED IN HIS CONDUCT THE SIMPLICITY OF THE GOSPEL.
LET MORTALS REJOICE THAT THERE HAS EXISTED SUCH AND SO GREAT
AN ORNAMENT OF THE HUMAN RACE.
BORN 25 DEC., 1642; DIED 20 MARCH, 1727.

tified with the theory of gravitation. Legend has it that his attention was forcibly called to gravitation by the fall of an apple upon his head as he rested beneath an apple tree. Voltaire is the authority for this anecdote and he is said to have obtained his information from Newton's favorite niece. But whether the apple legend is true or untrue, it is a fact that Newton's thoughts and researches upon gravitation have changed our conceptions of the universe. He began his researches when a lad of but twenty-four years; in 1665 and 1666 when the plague had driven him and all other students from Cambridge, Newton said: "I was in the prime of my age for invention, and minded mathematics and philosophy more than at any time since."

The great Galileo died the year Newton was born and it was his invention of the telescope and his planetary observations that prepared the way for Newton's discovery. John Kepler, follower of the master astronomer, Tycho Brahe, had reduced to simple laws the movements of the planets, most important of which was the fact that they moved in elliptical orbits around the sun at one of the two foci. Why should a planet swing a closed orbit around the sun instead of shooting off in a straight path? The mathematical genius of Newton proved that if there existed an attracting force between the sun and the earth that varied inversely proportional to the square of the distance between the two bodies, the earth would sweep the identical orbit around the sun that Kepler had observed. Experience with falling bodies and the weight of things suggested that the earth attracts bodies far from it just as it attracts a falling stone. Again Newton's calculations proved his theory right and the moon was shown to be but an immense stone ever falling toward earth and so kept in its orbit. The earthly force of gravity became a heavenly force as well.

Newton said: "I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

THE SCIENTIFIC MONTHLY

MAY, 1927

DID MAN ORIGINATE IN CENTRAL ASIA?

(MONGOLIA THE NEW WORLD, PART V)

By Professor WILLIAM K. GREGORY

AMERICAN MUSEUM OF NATURAL HISTORY

Dr. William Diller Matthew[1] and Professor Henry Fairfield Osborn[2] have long been the major prophets of the Dawn Man in Central Asia. Dr. Roy C. Andrews has sought him there with much labor but in vain. It has remained for Drs. J. G. Andersson and O. Zdansky to put the Dawn Man firmly on the map of China.

In an ancient cave at Chou Kou Tien, southwest of Peking, Dr. Andersson, of the Geological Survey of China, in 1921 discovered a rich fossiliferous deposit, which was later surveyed, partially excavated and described by Dr. Zdansky, of the University of Upsala. In addition to fossil teeth and bones of various mammals found there, including bats and monkeys, there were "two specimens of extraordinary interest, namely, one premolar and one molar tooth of a species which cannot otherwise be named than Homo? sp."[3] "One of the teeth recovered," Dr. Black states, "is a right upper molar, probably the third, whose relatively unworn crown presents characters which appear from the photographs to be essentially human. . . . The other tooth is probably a lower anterior premolar," the crown of which is "practically unworn and appears in the photograph to be essentially bicuspid in character, a condition usually to be correlated with a reduction of the upper canine." As to the age of the deposit and of the embedded human teeth, Drs. Andersson and Zdansky consider that the Chou Kou Tien fauna was possibly of Upper Pliocene age, but Dr. Black notes that in the light of recent research it is possible that the horizon represented by this site may be of Lower Pleistocene age. "Whether it be of late Tertiary or of early Quaternary age, the outstanding fact remains that for the first time on the Asiatic continent north of the Himalayas, archaic hominid fossil material has been recovered, accompanied by complete and certain geological data. The actual presence of early man in eastern Asia is therefore now no longer a matter of conjecture."

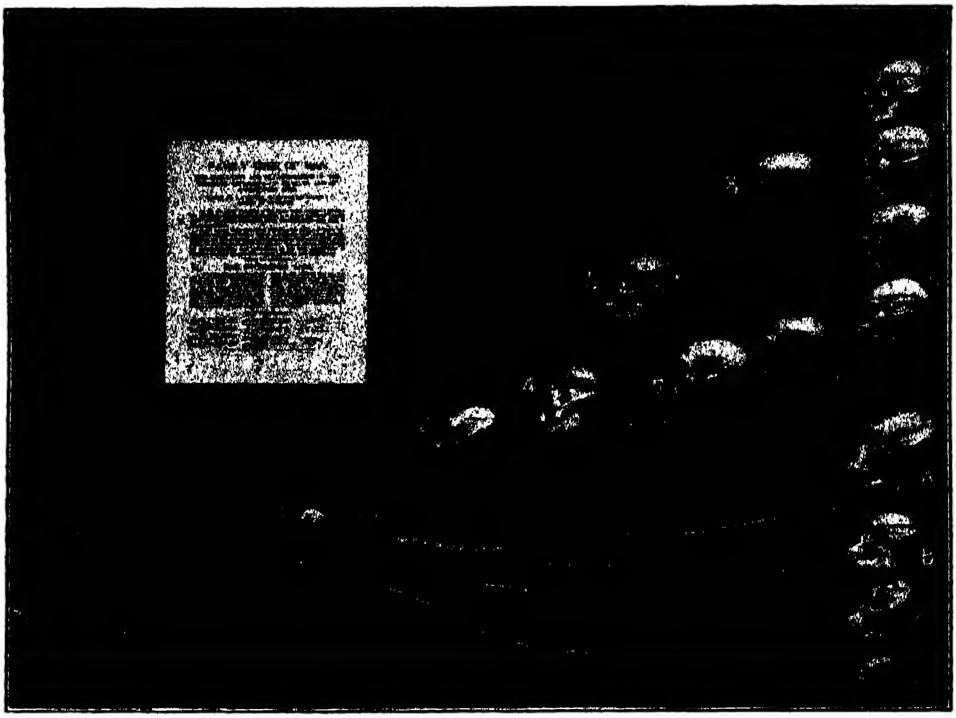
Dr. Black further notes that the Chou Kou Tien molar would seem to resemble in general features a certain fossil molar tooth described in 1903 by the eminent German paleontologist, Max Schlosser, which tooth had been purchased in a Peking drug store.[4] From the nature of its fossilization Schlosser considered the

[1] "Climate and Evolution," Ann. N. Y. Acad. Sci., 1915, XXIV, pp. 209–214.

[2] In various articles in *Asia* and *Natural History*.

[3] Black, Davidson, "Tertiary Man in Asia: The Chou Kou Tien Discovery." *Science*, Vol. LXIV, Nov. 17, 1926, pp. 586, 587.

[4] The Chinese use ground-up fossil "dragon bones" as medicine.



THE ASCENT OF MAN FROM LOWER PRIMATES, AS INFERRED BY WILLIAM K. GREGORY, 1924

Key to Stages

1. PRIMITIVE PRIMATE (*Notharctus osborni*). FOSSIL SKULL AND JAW, SLIGHTLY RECONSTRUCTED, OF EOCENE AGE, WYOMING. ORIGINAL IN AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.
2. PROTOTYPAL ANTHROPOID. RECONSTRUCTION BASED ON FOSSIL JAW (*Propliopithecus haeckeli*) OF OLIGOCENE AGE, EGYPT. ORIGINAL JAW IN STUTTGART MUSEUM, GERMANY.
3. PRIMITIVE ANTHROPOID, *Dryopithecus* sp. RECONSTRUCTION. PLACED HERE AS A REPRESENTATIVE OF A WIDE RANGE OF SPECIES, SOME OF WHICH ARE PROBABLY NEARER TO THE HUMAN BRANCH AND OTHERS TO THE VARIOUS ANTHROPOIDS.
4. TRINIL APE-MAN. RECONSTRUCTION BASED ON FOSSIL SKULL-TOP (*Pithecanthropus erectus*), OF UPPER PLIOCENE OR (MORE PROBABLY) LOWER PLEISTOCENE AGE, JAVA. ORIGINAL IN TEYLER MUSEUM, HAARLEM, HOLLAND.
5. PILTDOWN MAN. RECONSTRUCTION BASED ON FOSSIL SKULL AND LOWER JAW (*Eoanthropus dawsoni*), OF PLEISTOCENE AGE, ENGLAND. ORIGINAL IN BRITISH MUSEUM (NATURAL HISTORY), LONDON.
6. HEIDELBERG MAN. RECONSTRUCTION BASED ON FOSSIL JAW (*Homo heidelbergensis*), OF LOWER PLEISTOCENE, GERMANY. ORIGINAL IN UNIVERSITY OF HEIDELBERG, GERMANY.
7. NEANDERTHAL MAN. FOSSIL SKULL AND JAW, SLIGHTLY RESTORED, OF THE OLD STONE AGE, EUROPE. ORIGINALS IN PARIS MUSEUM OF NATURAL HISTORY.
8. CRO-MAGNON MAN. FOSSIL SKULL AND JAW, SLIGHTLY RESTORED, OF LATE PALEOLITHIC AGE, FRANCE. ORIGINALS IN PARIS MUSEUM.
9. AUSTRALIAN ABORIGINAL. ONE OF THE MOST PRIMITIVE OF EXISTING HUMAN RACES.
10. HOTTENTOT. REPRESENTING THE NEGROID GROUP OF RACES.
11. CHINESE. REPRESENTING THE MONGOLIAN GROUP.
12. AMERICAN. REPRESENTING THE CAUCASIAN GROUP.

A. GORILLA, AFRICA. B. CHIMPANZEE, AFRICA. C. ORANG-UTAN, BORNEO. D. GIBBON, INDIA.

RECONSTRUCTIONS NOS. 1, 3, BY OTTO FALKENBACH, UNDER DIRECTION OF WILLIAM K. GREGORY; NO. 2, BY MARCELLE ROIGNEAU, UNDER DIRECTION OF J. H. MCGREGOR AND WILLIAM K. GREGORY; NOS. 4, 5, 6, 7, 8, BY J. H. MCGREGOR.

specimen to be in all probability Tertiary in age, while from its detailed form he felt confident that it belonged either to a man or to a man-like anthropoid. He pointed out that future investigators might expect to find in China a new fossil anthropoid, Tertiary man or ancient Pleistocene man. "The Chou Kou Tien discovery thus constitutes a striking confirmation of that prediction" (Black).

Meanwhile Professor Osborn has on various occasions and with much force defended Reid Moir's claims for the human manufacture of certain types of apparently worked flints found embedded in strata of Pliocene age along the coast of Sussex, England. This, if confirmed by further evidence, dwarfs earlier ideas of the vast extent of man's antiquity. Herodotus says in substance that an aged Egyptian priest told Solon that the Greeks had hardly an inkling of real antiquity, that their ideas of ancient times were slight indeed compared with the records of hoary antiquity known to the priests of Egypt. But what were these records, what were even the mythological dynasties of the Hindus, extending into tens of thousands of years, compared with the antiquity of the Heidelberg man from the first Interglacial period of Europe, a matter of several hundreds of thousands of years? And what is that, in turn, compared with the antiquity of Pliocene man, which may be a million years or more?

To some it may seem almost sacrilegious to belittle thus the antiquity of the ancient temples of Asia. And what does late Pliocene or early Pleistocene man of China do to the traditional Eden in Mesopotamia of 4000 B. C.? On the other hand, do not such facts, if confirmed, bring ruin on the orthodox scientific theory of the origin of man from the stem of the anthropoid apes? Will they not indeed strongly support Professor Osborn, who in various publications prophesies the discovery of the remote ancestors of man in Central Asia, in formations of Oligocene or even Eocene age, and who, with the confidence born of a half century of brilliant paleontologic researches, also predicts that these ancestors will be found to be, not "apemen," but already upright-walking, large-brained Dawn Men of the plains?

Before attempting to answer these questions, let us consider first the great expansion of the idea of the earth's antiquity that has come even to geologists, accustomed as they were to figures of inconceivable magnitude.

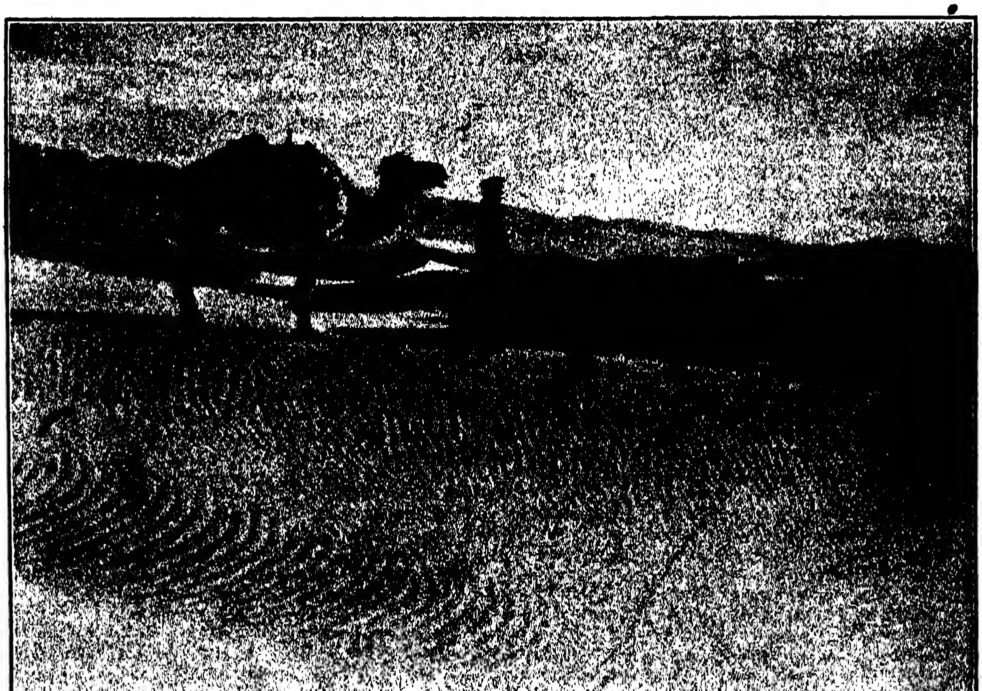
A couple of generations ago scientific estimates of the age of the earth and of the length of time represented by the rocks of any of the geologic periods were perhaps as inadequate as the Greek conception of human antiquity. The entire age of the earth was reckoned at less than a hundred million years, and the time from the beginning of the Tertiary period (the Eocene epoch) was estimated as a scant three million years. The most widely accepted of these estimates (by the eminent geologists Dana and Walcott) were based on the division of the known average rate at which the great river systems of the world are now carrying off their upland drainage basins and laying down deposits along the shores of the continents, into the total thickness of sedimentary rocks in the geologic column. But then came a succession of investigations and discoveries indicating that the present rate at which rocks are being formed is far too high to be taken as an average figure and that, on various accounts, the geologic column as a whole is vastly longer than it was supposed to be. The astronomers and geophysicists also were dissatisfied with the one hundred million years computed as the probable age of the earth by Lord Kelvin. These calculations were based on the theory of a slowly cooling earth but, from the researches of

Becquerel, Rutherford, Boltwood, Barrell[5] and others on radioactive minerals, there emerged the method of estimating the age in years of uranium and thorium ores, since the times of their crystallization from molten rock intruded between known geologic horizons. It was found that uranium gives off α, β and γ-rays at a constant rate and that it tends to disintegrate or transform from uranium, through several intermediate substances, including radium, into lead, the alpha rays being positively charged atoms of helium. It has also been found that the rate of disintegration of radium remains constant in spite of all efforts to modify it by subjecting it to temperatures up to 2500° C. and pressures up to 160 tons per square inch. It is deemed highly probable that the parent substance uranium is equally unaffected by any changes that it would be likely to encounter near the surface of the earth, so that its accuracy as a chronometer is relatively high. An atom of uranium which breaks up will ultimately give rise as stable products to eight atoms of helium and one of lead. In an unaltered dense crystalline rock the lead and helium also remain unaltered. It is estimated that a given quantity of uranium will disintegrate to half the original amount in six billion years.[6] The ratio of the weight of the helium and lead to the weight of the uranium in the sample will give the main basis for computing the age of the rock in years.

The late Professor Joseph Barrell, of Yale University, applying the results of

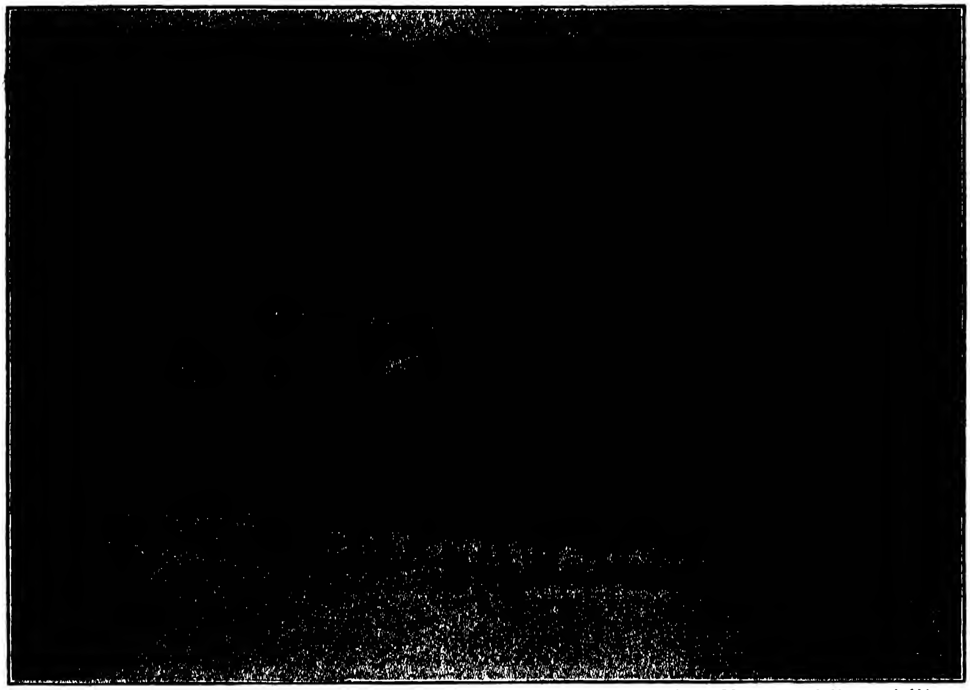
5 "Rhythms and the Measurements of Geologic Time," Bull. Geol. Soc. Amer., 1917, Vol. 28, pp. 745–904.

6 J Harlen Bretz, in "The Nature of the World and of Man." Univ. Chicago Press, 1926, p. 83.



Photograph by American Museum of Natural History

TSERIN, THE MONGOL GUIDE AND HUNTER OF THE EXPEDITION,
IN THE DUNES AT TSAGAN NOR.



Photograph by American Museum of Natural History

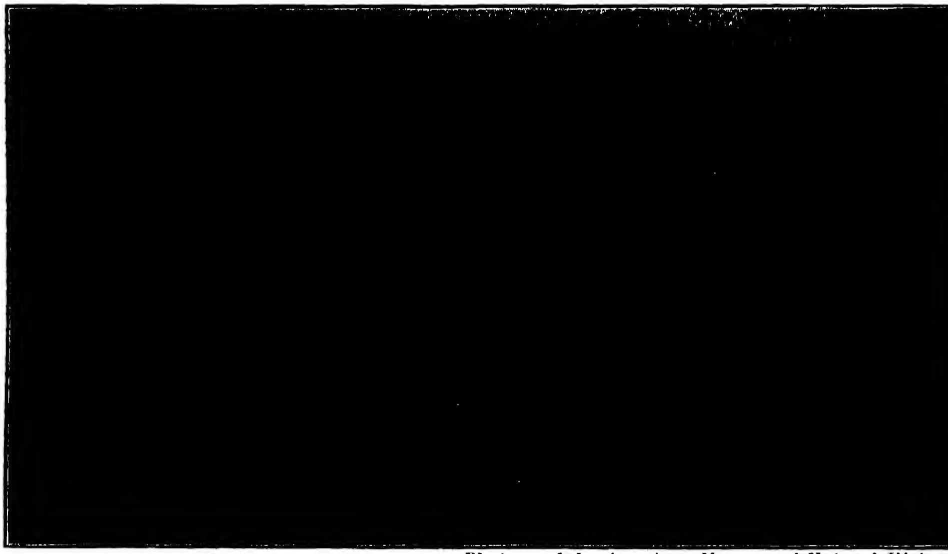
MERIN THE CAMEL LEADER

LEADING THE CARAVAN ACROSS THE DUNES OF TSAGAN NOR IN SEARCH OF WATER.

the "radium method" to rocks from various horizons in the geologic column, estimated that the oldest Precambrian granites measured were intruded 1,400,000,000 years ago and that the beginning of the Tertiary period (the Eocene epoch) would have to be set down as about sixty millions of years ago.

It is not to be supposed that geologists regard the figures arrived at from the "radium emanation" method as indicating much more than the general orders of magnitude of the successive ages. The estimates based on thorium ores are somewhat different from those based on uranium ores and all the estimates based on radium emanations are far greater than those obtained through any of the other methods of estimating geologic time. Nevertheless, the doubtful factors in the equations can perhaps never bring the estimates down to the scant figures obtained by Lord Kelvin and his immediate successors, and even the epochs of the Tertiary period may each represent millions of years, instead of hundreds of thousands, as formerly supposed. The Pliocene epoch in recent estimates is credited with a duration of six million years! Hence if man existed as such in the Middle Pliocene, as claimed upon strong evidence by Professor Osborn, his antiquity becomes inconceivably vast.

Our conceptions of the magnitude and wonder of nature have also had to expand in another direction. A "genealogical tree," representing, for instance, the evolution of mastodons and elephants during the Tertiary period, used to be conceived as a comparatively simple affair with a moderate number of branches and stems and a large but still comprehensible number of twigs and



Photograph by American Museum of Natural History

MR. NELSON MAKING THE PRELIMINARY CLASSIFICATION ACCORDING TO FORM

leaves. Moreover, the branches and twigs used to be represented in the diagrams as moving rather rapidly apart from each other and still must be so drawn, if the diagram is to be fitted on a single page. But many paleontological discoveries have proved that modern animals, such as the bear, cat, dog, horse, elephant, cow, pig, represent whole clusters of lines that have been separate from each other for enormous periods of time. Some of the horses of Pliocene times, for instance, were very little different in structural details from their existing relatives and descendants, the horses, asses and zebras. The Pliocene bears were already established in North America and but slightly different from some of their modern descendants. Again, many of the rodents have changed but very little in the same interval. Such discoveries as these have been made so often that not a few vertebrate paleontologists have been much more active in demolishing the "genealogical trees" set up by their predecessors than in working out new ones for themselves. It has become the fashion to exclude almost every known earlier form from ancestral relationship to every known later form. The "trees" have been broken up into nearly parallel lines, converging, if at all, only at infinity. On the side of classification, species are being promoted to genera, genera are raised to subfamilies, subfamilies to families, families to suborders, suborders to orders. Finally, in the case of fishes there is a well-marked tendency on the part of some authors to disregard the ordinal divisions and to present almost interminable lists of families, species and genera unrelieved by larger groups. Thus the ruins of the classifications of the elders seem at first sight to be deeply buried in masses of details.

However, leaving out of account for the moment the possibility that these tendencies and viewpoints may represent an extreme swing of the pendulum of human thought in a certain direction, and that the reaction may be even now under way, it is not the nature of science to remain long buried in its own ruins;

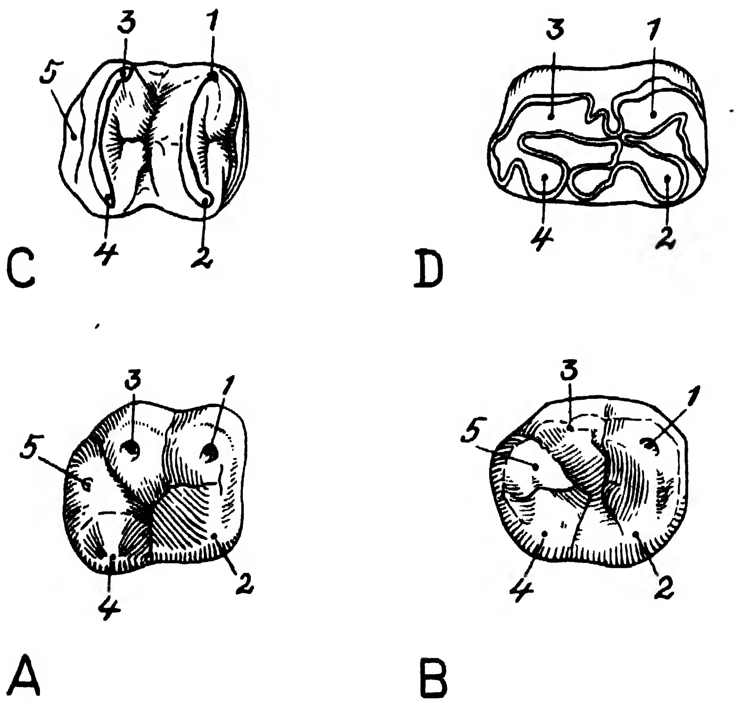


FIG. 1. MAN AND ANTHROPOID MORE NEARLY RELATED IN TOOTH STRUCTURE THAN HORSE AND TAPIR

A, B. LOWER MOLAR TOOTH OF FOSSIL *Dryopithecus* (A) AND EHRINGSDORF MAN (B). C, D. LOWER MOLAR TOOTH OF TAPIR (C) AND HORSE (D).

there is, in fact, distinctly another side to the story. Both geologic epochs and independent lines of mammalian descent are doubtless far more extended in geologic time than was suspected in the time of Huxley. But if, on the one hand, the individual epochs and the phylogenetic histories have lengthened, so, on the other hand, has the record lengthened as a whole, and consequently the *relative* lengths of the different epochs remain much as they were before. At first sight, Pliocene man may seem to us a being of inconceivable antiquity, but even if, according to the latest estimate, he existed as man more than a million years ago, he was even then many times nearer to us in time than he was to the beginnings of the primate stem in the Basal Eocene some sixty million years ago.

It may be true, as Professor Osborn implies, that the real ancestral home of the human family is as far back of the Pliocene epoch as that is back of the mythical Adam in the Mesopotamian paradise, so that proud mortals may comfort themselves in the thought that for millions of years they have belonged to a "superior" family of primate mammals. And by as much as geological time lengthens before us, by so much increases the apparent power of heredity to resist the pressure of environment and selection and to keep the general pattern of all organisms nearly true to type, especially in the preservation of "living fossils," or conservative forms, through vast ages. But there is assuredly a fallacy lurking in the reasoning that because the horses and the elephants and many other mammals changed very

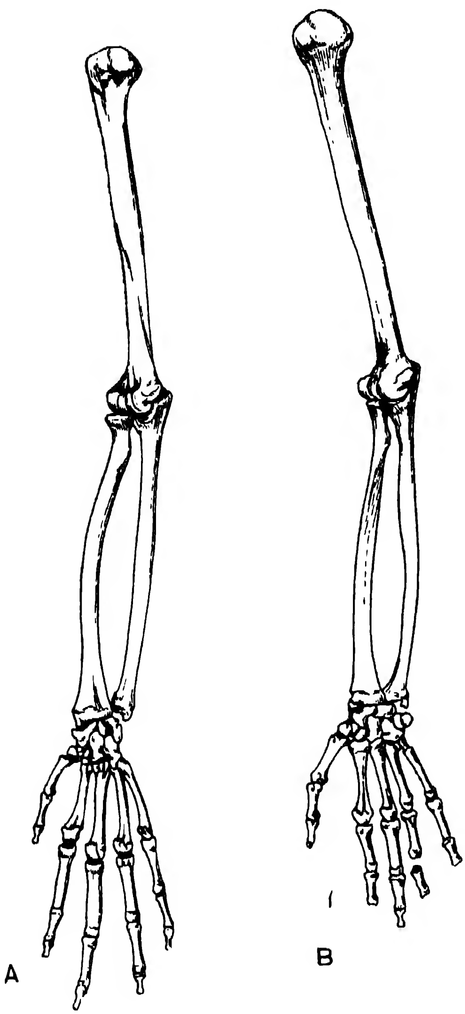


FIG. 2. ARM AND HAND OF CHIMPANZEE (A) AND VEDDAH (B)
AFTER FRITZ AND PAUL SARASIN.

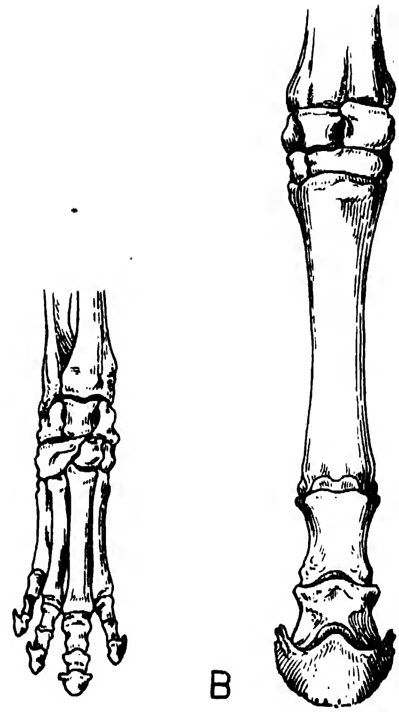


FIG. 3. HAND OF TAPIR (A) AND HORSE (B)

slowly during the Pleistocene, Pliocene and Miocene, and because Pliocene man was (it is assumed) already man, therefore the human family was distinct from all others as far back as the families of horses, tapirs, etc., were distinct from each other, namely, as far back as the Oligocene or even the Eocene. The implied assumptions that the structural evolution of man has proceeded at a constant, if almost infinitesimal rate, and that this rate is roughly the same as in the horses, tapirs, elephants, etc., not only lacks positive evidence but is certainly not in harmony with a great body of well-tested evidence from many sources.

In the case of the modern horses, tapirs and rhinoceroses—very diverse animals whose Lower Eocene ancestors were but slightly different from each other—nothing of the kind is better evidenced than the fact that structural evolution has proceeded at very different rates in the different families. The tapirs, for instance, after the lapse of all the millions of years since the Lower Eocene still retain many characters in the feet, limbs, backbone and low-crowned grinding teeth, which are in-

herited from the very remote common ancestors of horses, tapirs and rhinoceroses, while during the same time the horses have undergone far more radical changes and retained correspondingly fewer primitive characters in these structures. Obviously, if rates of evolution were uniform in all descendants of a common stock there could indeed be no science of comparative anatomy, because all animals of the present epoch would be in the same grade of organization and we should not find the conservatives, the progressives and the freaks living in the same epoch, as we frequently do. Moreover, it is widely recognized that in a given evolutional series certain structures, such as the teeth or the feet, may undergo far greater changes in a given period than other parts, such as the reproductive system, whereas in other series the teeth may be relatively conservative, even degenerative, while the brain may undergo great changes, as in the toothed whales.

The very existence of many independent, slowly divergent phyletic lines within each given family of the titanotheres, horses and rhinoceroses—all distinguished by quantitative or proportional differences in their several parts—as so abundantly documented by Professor Osborn in America and by Depéret, Stehlin and others in Europe, affords definite evidence for the statement that during a given period rates of evolution are not uniform, even in allied series, and this is true whether we are considering special parts, such as the molar teeth, the feet, the brain or the total amount of evolution in the skeleton as a whole, as when we compare the skeletons of the modern tapir and of the horse with that of the primitive *Eohippus* of the Lower Eocene. Hence we are by no means warranted in assuming that because the common ancestors of other divergent families are to be sought at least not later than in the Lower Eocene, the same will prove true of the human family and of its nearest relatives among the other primates.

Even if it be fully proved in the future that all Pliocene men were as nearly like modern men as the most progressive of the Pliocene horses were like modern horses, it by no means follows that modern man is as far removed in relationship from the chimpanzee as the horse is from the tapir (Figs. 1–3). To the extent that degrees of structural resemblance or difference may correspond with degrees of genetic relationship we may affirm that on the whole man is much nearer to the chimpanzee and gorilla than the horse is to the tapir (Figs. 1, 2). In fact, in one of Professor Osborn's "Pliocene Dawn-Men" (*Eoanthropus*) the lower molar teeth so far as known are almost generically indistinguishable from those of the Pliocene anthropoid *Dryopithecus* (Fig. 4), and the Pleistocene man, *Homo neanderthalensis,* retains in his lower and upper molars the clearest evidence of his proto-anthropoid derivation, in spite of the wide divergence in foot structure of plains-dwelling man and forest-living ape (Fig. 5).

If we grant for the moment that the structural difference between two diverse members of a single group is roughly proportional to the time since they diverged from each other, then, as the structural difference between man and chimpanzee is on the whole far less than the difference between horse and tapir, so the time of separation between man and chimpanzee should be far less than the time of separation of horse and tapir. Therefore the lines of man and the chimpanzee should run together at a period far later than the Lower Eocene, which is the approximate time of separation of the lines leading to horse and tapir. If, on the other hand, man and the chimpanzee were on separate lines as far back as were the horse and the tapir (Lower

FIG. 4. LOWER MOLARS (LEFT) OF PILTDOWN HUMAN JAW (A) AND OF FOSSIL ANTHROPOID *DRYOPITHECUS FRICKAE* (B)

Eocene), then the rate of divergence must have been far slower between man and anthropoid than between horse and tapir. This again is an assumption contrary to present evidence from comparative anatomy, which indicates a remarkably high range of heritable variability and consequent instability, in both human and anthropoid stocks, as compared with the variabilities in tapirs and horses.

Sonntag's "Morphology and Evolution of the Apes and Man" and similar works record a large number of detailed anatomical differences between modern apes and man, differences which have doubtless accumulated during the millions of years during which the apes have become specialized for arboreal life and man for terrestrial life. But along with these differences are hundreds of peculiar features common to man and his nearest relatives, the chimpanzee and the gorilla. Since the time of the great English anatomist Tyson (1699) it has been recognized that the chimpanzee in the totality of his anatomical characters stands far nearer to man than to the lowest existing primates. The laborious researches of students of the human brain, culminating in the recent work of Professor Tilney, reveal the most striking unity of plan in the basal architecture of the brains of gorilla and man. And when the evidence afforded by comparative embryology is sought, the relatively close kinship of man with the chimpanzee and gorilla becomes indubitably clear, as in the recent studies of

FIG. 5. FOOT OF ARBOREO-TERRESTRIAL GORILLAS AND TERRESTRIAL MAN
AFTER SCHULTZ

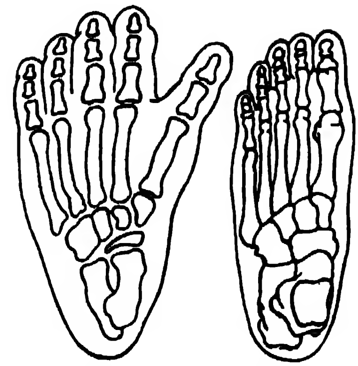


FIG. 6. DIAGRAM OF RADIOGRAPHS OF HUMAN FOOT
FETAL (NINTH WEEK, ENLARGED) AND ADULT HUMAN FOOT. AFTER SCHULTZ. IN THE EARLY FETAL STAGE THE FOOT IS PLAINLY SUGGESTIVE OF ANTHROPOID DERIVATION.

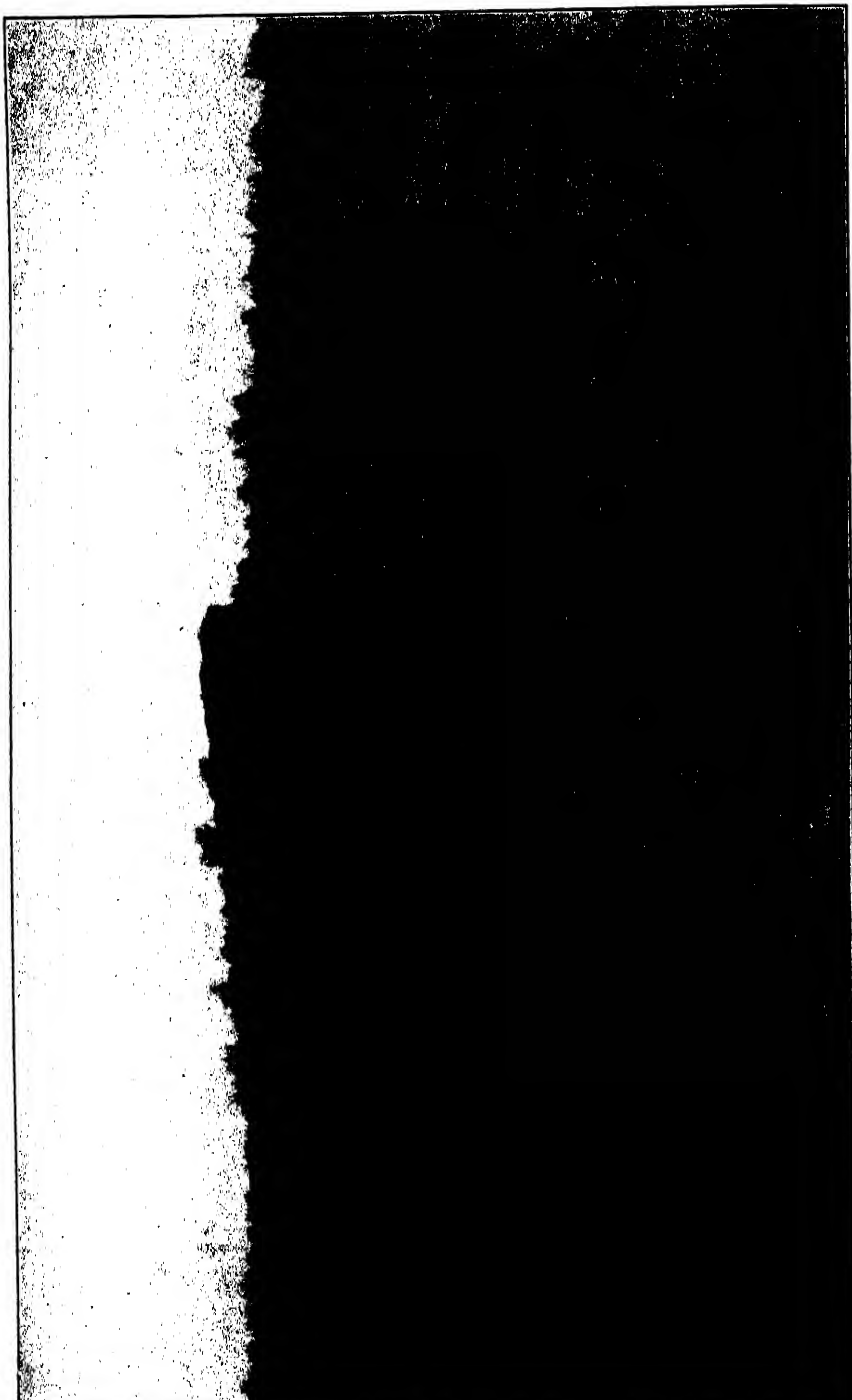
Professor Adolph H. Schultz, of Johns Hopkins University.

So many and deep-seated are the anatomical and physiological bonds between the anthropoid apes and man that Professor H. H. Wilder has proposed to recognize this relationship by referring the existing anthropoid apes and man to a single zoological family, the Hominidae. In other words, according to the viewpoint held by Wilder, Schwalbe, Keith, Elliot Smith, Sonntag, Tilney and many other recent investigators, including the present writer, the existing anthropoids and man are merely divergent branches of a primitive anthropoid stock, exactly as held by Darwin. To deny at this date or to seek to minimize the importance of man's close relationship with the chimpanzee-gorilla stock, is to shut one's eyes to a vast accumulation of well-tested facts. To attribute to parallelism the thousands of resemblances between man and chimpanzee is equivalent to saying that no zoological classification founded on deep-seated anatomical resemblance has any objective validity.

No matter how many millions of years ago man and the chimpanzee parted company, the anthropoid apes are still justly regarded as man's nearest relatives among existing mammals and the most intensive research has brought forth no adequate reason for doubting that man is an offshoot from the Old World Primates and in particular that he represents a highly modified offshoot of the anthropoid stem.

It is true that a few authors have failed to grasp this fundamental fact and that all sorts of queer theories have been promulgated, but at the present time the weight of a great many independent investigations is overwhelmingly in favor of the view that at one time man passed through an arboreal stage of life, not remaining there long enough to become over-specialized in that direction like the existing anthropoids, and that at a later period he came down out of the trees, preserving his erect arboreal posture and becoming a bipedal cursorial animal.

But what has all this to do with Mongolia and with the question whether man originated in Central Asia? In the first place, man, according to the view here defended, belongs in the Old World division of the higher Primates. Darwin with his usual sagacity grasped this fundamental truth and argued with force that we should not look to the New World series for the ancestry of man.



Photograph by American Museum of Natural History

THE DUNES OF SHABARAKH USU

ANDREWS, NELSON AND YOUNG INVESTIGATING THE SITE WHERE THE DUNE DWELLERS CAMPED IN STONE AGE TIMES.

The subsequent efforts of Ameghino and others to attach man to the platyrrhine or New World stem, have only brought out the soundness of Darwin's position. Up to the present time all the evidence from geographic distribution and from paleontology is in favor of the view that the "Old World" series arose somewhere in the eastern hemisphere. The oldest representatives of the Old World series so far known are found in the Lower Oligocene of Egypt as primitive forerunners of the anthropoid apes. The southeasterly outlying parts of the Eastern hemisphere, including New Guinea and Australia, are, so far as known, devoid of all traces of the anthropoid stock, except in so far as man reached there in relatively late times. As to North America, however early man may have reached there, *Hesperopithecus* of the Pliocene of western Nebraska, if it is an anthropoid, may well be an immigrant along with certain other mammals, from the presumed center of distribution in Asia.

Man is very definitely to be classified, according to his anatomic and physiologic characters, as an offshoot of the anthropoid stem. Where then is the ancestral home of that stock? At present the anthropoid apes are found from Borneo and Sumatra on the southeast to West Africa on the west, but in former ages representatives of the group at different times penetrated as far west as Spain and as far south as South Africa, with India as a definitely known area of anthropoid radiation in Upper Miocene and Lower Pliocene times.

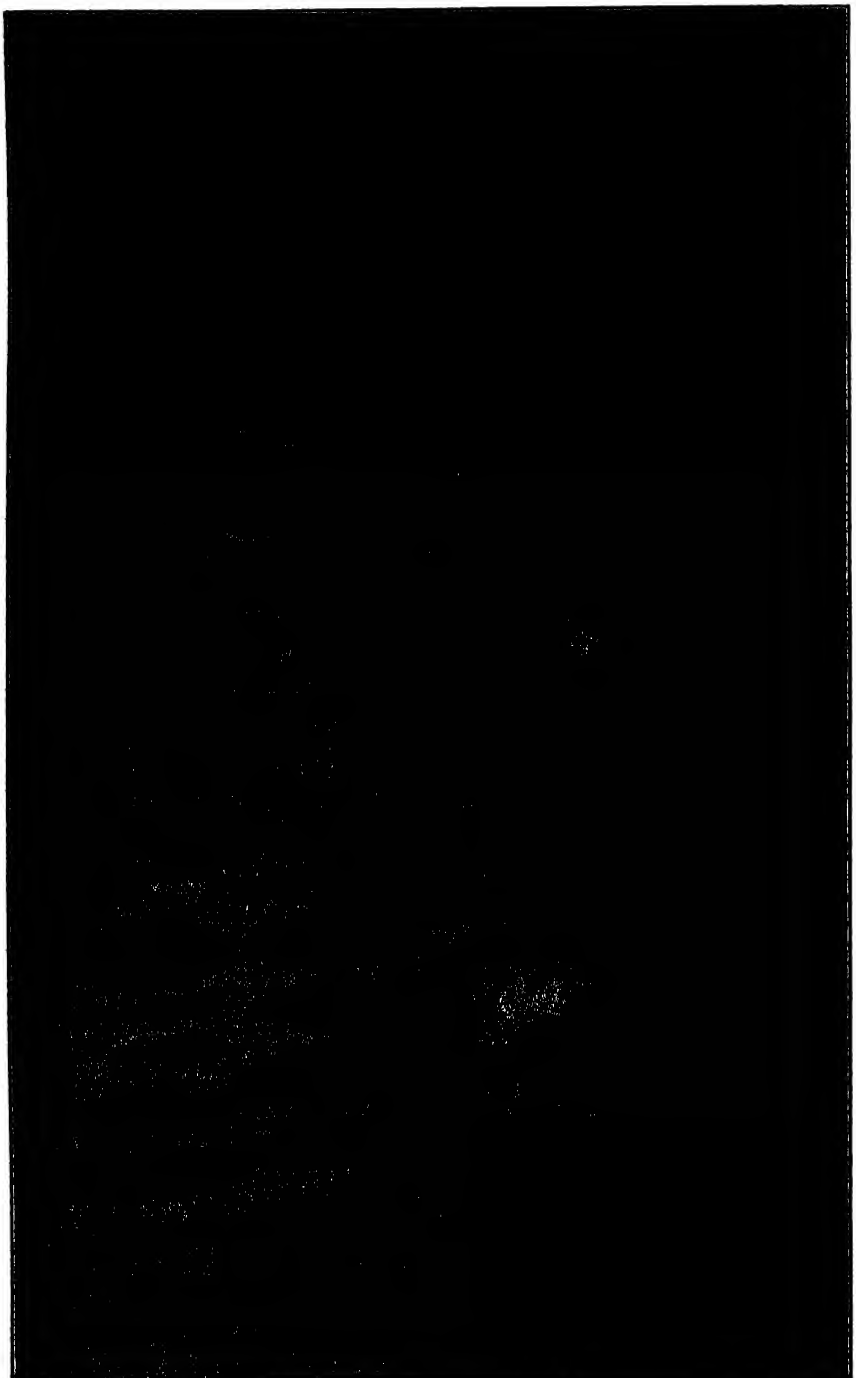
According to the conclusions arrived at in the studies of Hellman and the present writer on the dentition of *Dryopithecus* and allied genera, the known fossil Indian anthropoids appear to be allied rather with the far eastern orangs than with the western division, which, according to our view, includes the gorilla, chimpanzee and man. In fact, as it appears to us, the nearest approach to human conditions is made by *Dryopithecus rhenanus* of the Pliocene of Europe, rather than by any of the Indian anthropoids and, as already stated, the lower molars of the Piltdown Dawn Man, so far as known, appear to be generically close to those of *Dryopithecus.*

But this does not necessarily indicate that the evolution of man took place in Europe, as Dr. Hrdlička[7] holds. Europe, Asia and parts of Africa have been in more or less continuous contact for millions of years[8] and it is a risky thing to argue that because Europe has yielded some of the most primitive known fossil men (Piltdown, Heidelberg, Ehringsdorf) and some of the most man-like apes (referred to *Dryopithecus rhenanus*) therefore the transition occurred in Europe, especially in view of the evident complexity of the migrations and counter-migrations of the fossil mammalian faunas between Asia, Europe and North America.

It is equally unwarranted to claim that because very ancient and primitive members of the man-anthropoid series have been found in the Lower Oligocene of Egypt, therefore Africa was the original center, inasmuch as the strictly geological record indicates that Egypt at that time was in broad contact with Southern Asia (Grabau and Black, *op. cit.*, pl. VI). Such claims should be allowed only after a careful and minute analysis of the geologic evidence tending to show what avenues of distribution may have been open, and after an

[7] "The Peopling of the Earth," Proc. Amer. Philos. Soc., 1926, Vol. LXV, No. 3, pp. 150–156.

[8] Compare the geological evidence summarized by Matthew, "Hypothetical Outlines of the Continents in Tertiary Times," Bull. Amer. Mus. Nat. Hist., Vol. XXII, pp. 353–383, and by Grabau (in Black, Davidson, "Asia and the Dispersal of the Primates," Bull. Geol. Soc. China, 1925, Vol. IV, No. 2, pp. 133–183).



Photograph by American Museum of Natural History

EXAMPLES OF POTTERY AND VARIOUS TYPES OF ARTIFACTS MADE BY THE DUNE DWELLERS OF THE GOBI

equally thorough comparison of the given fauna and of its elements with those of earlier and later faunas elsewhere. Such an analysis has been made by Professor Dart of the conditions under which lived the most man-like anthropoid, *Australopithecus*, of South Africa. But it may be suspected that *Australopithecus* represents the extreme southward thrust of the chimpanzee stock after it had separated from man.

The existence of *Pithecanthropus* and the primitive Wadjak and Australian human skulls at points far to the southeast of the Asiatic uplands is consistent with the view that the center of dispersal of the human series was in some relatively central region. Finally the recent discovery of ancient man (of Pleistocene or Pliocene age) in China tells strongly in the same direction.

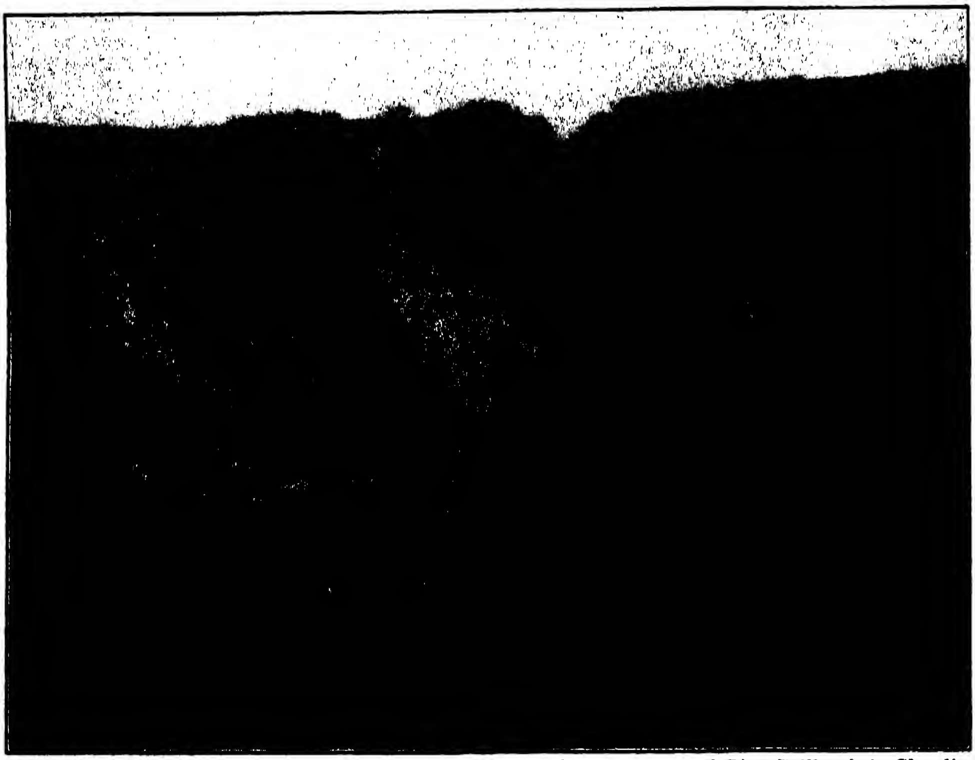
The Central Asiatic expedition should therefore be encouraged to search with all zeal for evidence of the origin of man in Oligocene and Eocene formations of Mongolia, but the members of the expedition should not be downhearted if no such traces be found at that very low horizon.

Dr. Black's masterly synthesis of geologic, paleontologic and anthropologic data leads him to conclude (pp. 174–179) that the differentiation of the human from the proto-anthropoid stock took place in correlation with the slow but progressive elevation and desiccation of the vast Central Asiatic region. During the Eocene the land was low and covered with semitropical rain forest; during the Oligocene the rise of the Himalayas was a time of great forests like those of parts of modern Ceylon. In Miocene time forests of more northern character interspersed with open stretches of savannah became prevalent, till before its final elevation in the Pleistocene the region became one of open plains and restricted wooded areas. Meantime, Dr. Black points out, these changes in the environment would tend to increase, if they did not initiate, the cleavage between the proto-human and the (modern) great anthropoid stocks. The latter, a conservative group, were characterized by relatively early maturity of growth and inability to become modified with the changing environment. They therefore tended to migrate along with their own kind of environment and scattered remnants of the great forested areas. The second or progressive group early developed a tendency toward a prolonged period of childhood, resulting in a retarded maturation of the skull and great relative and absolute increase in the volume of the cerebrum. By reason of the resulting increase in mental capacity this group became increasingly adaptable to the change from forest to open country and gave rise near the center of its origin to group after group of successively higher types; the older, more archaic types being pushed away to the periphery, in accordance with the principle developed by W. D. Matthew.

Finally, Dr. Black, from geologic data assembled by Grabau, points the way to future exploration in the Yung Ling range of the Tibetan Alps as the most likely region in which to search for remains of the more conservative group, while he looks to the Tertiary deposits of the Tarim region to the north of Tibet for possible traces of early members of the plains-living proto-humanoid and early human stock.

Meanwhile considerable progress has already been made toward discovering the sequence of early human cultures in China and Mongolia. Père Licent, director of the Tientsin Museum, and Père Teilhard de Chardin,[9] of the Paris Museum of Natural History, in 1923 discovered at Choei-tong-k'eou in the vicinity of Ordos, in the great bend of the Hoang-ho river, a great quantity of

[9] "Fossil Man in China and Mongolia," *Natural History*, May–June, Vol. 26, p. 238.



Photograph by courtesy of Père Teilhard de Chardin

PALEOLITHIC BEDS OF CHOEI-TONG-K'EOU

AT THE TIME OF DISCOVERY. THE "HEARTH" BEGINS AT THE POINT WHERE THE MAN AT THE RIGHT TOUCHES THE CLIFF.

coarse implements of quartzite-worked flakes or blades similar to the Mousterian and Aurignacian implements of Europe, and small flint implements of much finer type. These were found in "hearth" sites buried under at least fifty feet of loess formation, and show that man inhabited this site at the commencement of the formation of the loess. Bones of the kiang, aurochs, argali sheep, gazelle, woolly rhinoceros, hyena and ostrich were found on the same hearths. In other localities of this region Pères Licent and Teilhard found traces of Paleolithic man at a depth of some 180 feet below the actual level of the steppe. Père Teilhard concludes that the discovery of worked quartzites in gravels at the base of the loess at Sjara-osso-gol, proves "that Paleolithic man lived in China not only during the formation of the loess but from its very beginning and perhaps even earlier. Thus man has seen China without its mantle of Yellow Earth, which gives us a vivid realization of his antiquity in the Far East. Great as it is, however, this antiquity is as yet less than the known antiquity of man in the West. The loess, as we have said, seems to correspond to the latest stages of the Glacial Epoch in Europe and North America. If this is true, then man of the Yellow Earth is far more recent than, for instance, man of the gravels of Chelles and Saint Acheul."

From later ages, including Mesolithic, Neolithic and pre-Mongol horizons, Dr.

Nels C. Nelson,[10] of Dr. Andrews' expedition, has collected a large series of flint implements and other cultural remains in different localities in Mongolia and China. In this way the very remote past of man in these countries is gradually being tied in with later history, the geologists and archeologists together tracing the rhythmic alternation of more arid and more humid climates and their effects upon the human populations.

10 "The Dune Dwellers of the Gobi," *Natural History*, May–June, 1926, Vol. 26, p. 246.

CARL FRIEDRICH GAUSS

THE SESQUICENTENNIAL OF THE BIRTH OF GAUSS

By G. WALDO DUNNINGTON
WASHINGTON AND LEE UNIVERSITY

On April 30, 1927, fell the one hundred and fiftieth anniversary of the birth of Carl Friedrich Gauss, the mightiest mathematician since the day of Sir Isaac Newton. Indeed, some writers have ranked him as the equal of the latter, but this question had better be left undecided, since Gauss himself would be the first to give place to Newton, to whom he always applied the adjective *summus*. Gauss has been called the "prince of mathematicians" and "Archimedes of the nineteenth century."

It seems that the higher the genius of a man, the later does a definitive biography of him appear, notwithstanding the recent flood of biographies. Several monographs in German have been published, but as yet no definitive biography of Gauss has appeared. A committee of scholars at the University of Göttingen is still engaged in editing the works of this scientist, and in studying notes left at his death. In the rooms he formerly occupied there has been fitted up a Gauss-archive.

Gebhard Dietrich Gauss was born on February 13, 1744, and assisted his father in business at Brunswick, Germany. On April 28, 1768, he married Dorothea Emerenzia Warnecken Sollerich, and to this union was born one son, Johann George Heinrich, on January 14, 1769. The mother died on September 5, 1775, aged thirty years. Gebhard Dietrich married (on April 25, 1776) Dorothea Bentze, the daughter of Christopher Bentze, a stone mason in Velpke, a small village near Brunswick. Their only child, Carl Friedrich Gauss, was born on April 30, 1777.

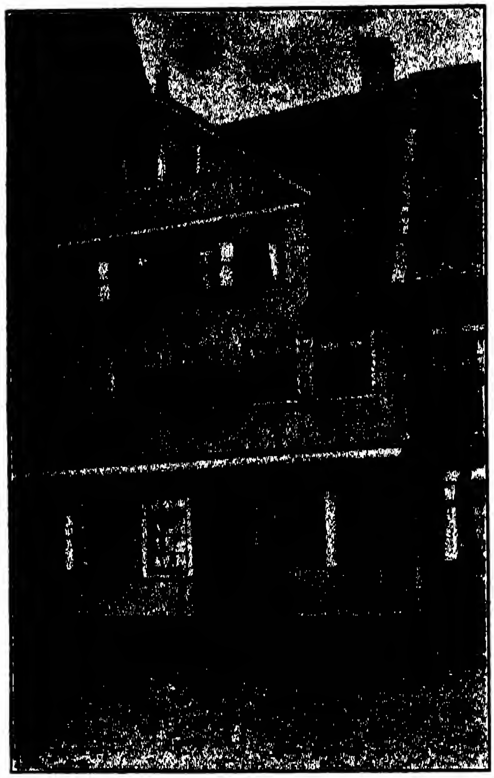
The house where this important event occurred has been well preserved. The late George Hieb was largely responsible for the establishment of a room in this house at No. 30 Wilhelmsstrasse (formerly Wendengraben), where one may see all sorts of Gauss relics, such as furniture, letters, books, photographs of his near relatives and many descendants.

Dorothea Gauss reached the ripe old age of ninety-seven and spent the last twenty-two years of her life under the loving care of her son at the Göttingen observatory. Gauss and his father never had any quarrels, but in his home Gebhard Dietrich was often dominating and uncouth. He died on April 14, 1808.

According to Gauss' own story, his mother could not tell him the exact day on which he was born: she only knew that the birthday fell on Wednesday, eight days before Ascension. This circumstance was the occasion of his discovering the formula by which one can reckon the day of the month on which Easter falls, for any year.

He often said that he could count before he could talk. Many stories are told of his precocity. At the age of seven, in 1784, he was sent to school, and for two years instructed by Büttner in reading and writing, with nothing as yet appearing to distinguish him especially from his fellow pupils. However, when he reached the arithmetic class he soon attracted the attention of Büttner.

Johann Christian Martin Bartels was Büttner's assistant, and a young mathematician of no mean ability. He took a great interest in this promising young child, furnished him the necessary books and taught him the theory of infinite



THE BIRTHPLACE OF CARL FRIEDRICH GAUSS IN BRUNSWICK

series and analysis. In 1788, young Gauss entered the gymnasium; here he showed great ability in the ancient languages. Through Bartels, Privy Councillor von Zimmerman informed the Duke of Brunswick, Carl Wilhelm Ferdinand, in 1791, about the case of Gauss, whose father was opposed to the continuance of his education. The duke resolved to furnish further means for the child's education.

As a protégé of the duke, Gauss entered the Collegium Carolinum in 1792. There he learned the modern languages and continued his study of the ancient languages. Even at his age this youth carried on private mathematical researches during this period.

In 1795, Gauss entered the University of Göttingen, still undecided whether to devote his life to mathematics or philology. On March 30, 1796, one event, more than any other, enabled him to decide this question, *viz.*, the discovery of a method of inscribing a regular polygon of seventeen sides in a circle, with straightedge and compasses. Gauss always considered this one of his greatest discoveries, possibly due to the fact that it had escaped the eyes of mathematicians for two thousand years. The complete theory of circle-division and primes was elaborated in his immortal work, "Disquisitiones arithmeticae" (1801). This treatise is widely conceded to be the greatest piece of human ingenuity since the publication of Newton's "Principia." The visitor to the park in Brunswick to-day can see on the Gauss monument there a regular polygon of

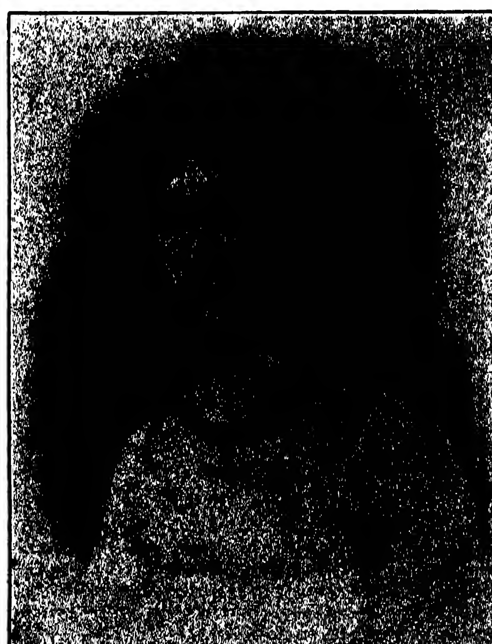
THERESA GAUSS
THE YOUNGEST CHILD OF C. F. GAUSS

seventeen sides engraved on the base. This monument is by Schaper.

In a letter to Schumacher, Gauss says that he had used the method of least squares since 1794. One of Gauss' student friends was Johann Joseph Anton Ide, also from Brunswick: he became professor of mathematics at the University of Moscow, and died there in 1806. However, his most intimate friend was Wolfgang Bolyai, a Hungarian who was somewhat older than Gauss. They would take long walks together, discussing metaphysical views on mathematics. A frequent topic of conversation was Euclid's axiom of parallels; many prominent scientists had made attempts to prove this axiom. It later occurred that Bolyai's son Johann published a little volume on non-euclidean geometry. Gauss read this, praised it highly, said that the contents coincided with his own investigations, and declared that he was glad to have been anticipated in this field by the son of his old friend. The correspondence between Bolyai and Gauss continued up to the death of the latter.

On July 16, 1799, Gauss received his doctorial degree; the thesis topic was: "Demonstratio nova theorematis omnem functionem algebraicam rationalem integram unius variabilis in factores reales primi vel secundi gradus resolvi posse." This was the first rigorous proof of the fundamental theorem of algebra, which he had already discovered in October, 1797. He gave two new proofs in 1815 and 1816; on July 16, 1849, at the celebration of his fiftieth anniversary of attaining the doctorate, Gauss gave the first proof of 1799 in altered form.

On New Year's day, 1801, Piazzi in Palermo discovered a star of the eighth magnitude, which he thought was a new comet. Piazzi's excellent observations showed that this body moved in a circular orbit, rather than a parabolic orbit, as required for a comet, between Mars and Jupiter. The astronomer Olbers, an



MINNA WALDECK GAUSS
SECOND WIFE OF CARL FRIEDRICH GAUSS
(FROM A PASTEL PORTRAIT).

intimate friend of Gauss, rediscovered this planet and informed him about it. He at once set to work to calculate the orbit from the given data, according to Kepler's laws. Suffice it to say, he formulated a method of computing *elliptic* orbits, which placed him in the first rank of astronomers for all time. This asteroid was later named Ceres. In the summer of 1802 he took observations of Pallas. The direct outcome of this work in astronomy was the publication at Hamburg in 1809 of his "Theoria motus corporum coelestium in sectionibus conicis solem ambientium." For this epoch-making work he received the Lalande Prize of the French Academy in 1810. In 1802 the Czar of Russia had attempted to secure Gauss as director of the observatory at the Petrograd Academy and later efforts were made to secure him for Berlin and Vienna, but all these overtures failed.

After his return from Göttingen, Gauss was a frequent visitor at the home of George Carl Ritter in Brunswick. Here he became acquainted with Johanna Osthoff in 1803; she was the daughter of Christian Ernst Osthoff, a man of moderate means, proprietor of a local tannery. Johanna was the only child, born on May 8, 1780, the pride of her parents, spirited, kind, happy and gifted with understanding. From the very beginning Gauss felt himself attracted to her, and on July 12, 1804, wrote her the following letter:

My true friend, receive favorably the fact that I pour out my heart, in writing, before you, about an important matter, regarding which I have found no proper opportunity to mention up to the present.

Finally, let me say it from the fullness of my heart, that I have a heart for your silent angelic virtues, an eye for the noble features which make your face a true mirror of these virtues. You, dear modest soul, are so far removed from all vanity that you yourself do not realize your own value; you don't know how richly and kindly heaven has endowed you. But *my* heart knows your worth—O! more than it can bear with repose. For a long time it has belonged to you. You won't repel it? Can you give me yours? Dear, can you grasp the proffered hand, do it gladly? My happiness hangs on the answer to this question. Indeed, at present I can't offer you riches or splendor. Still, dear, I can not have erred as to your beautiful soul—you are certainly as indifferent to riches and splendor as I am. But I have more than I need for myself alone, enough for two young people to start a carefree, agreeable life, not thinking at all of my prospects for the future. The best that I can offer you is a true heart full of the warmest love for you.

Ask yourself, beloved friend, whether this heart completely satisfies you, whether you can reply just as sincerely to its feelings, whether you can contentedly make the journey of life hand in hand with me, and decide soon.

I have placed before you, darling, the desires of my heart in artless, but candid words. I could have done it in entirely different words. I could make for you a portrait of your charms, which you, although it would be nothing more than the truth, would have received as flattery; with burning colors I could make for you a picture of my love—to be sure, there I would be allowed only the expression of my feeling—a portrait of the bliss or disconsolation which await me ever after you have accepted or rejected my desires. But I didn't want to do that. At least, don't mistake the pureness of my unselfish love. I don't want to bribe your decision. In the sincerest concern of your life you must not allow any unusual considerations to influence you. You are not to bring a sacrifice to my happiness. Your own happiness alone must guide your decision. Yes, dearest, so warmly do I even love you, that only possession of you can make me happy, if you are of the same feeling.

Dearest, I have exposed to you the inner part of my heart: passionately and in suspense am I waiting for your answer.

With all my heart,
Yours,
C. F. Gauss.

Brunswick, 12 July, 1804.

Three months passed before the wooer received an answer to this letter. Johanna loved Gauss, but through idle gossip had heard the name of a wealthy young lady connected with that of Gauss. This report having been corrected, the two became engaged on November 22, 1804; three days later the young lover said to a friend, "Life

stands like an everlasting spring with new glittering colors before me." On October 9, 1805, Gauss and Johanna were married and occupied the apartment he had had as a bachelor at Ritter's house.

Their first child, Joseph, was born here on August 21, 1806; there are reasons for believing that he was his father's favorite child. Joseph became a Hanoverian artillery officer, and later visited the United States in the late thirties, then became Oberraurath and member of the department of Hanoverian railroads and telegraphs, his death occurring on July 4, 1873. He married Sophie Erythropel, daughter of a physician in Stade, born on January 20, 1818, and died on April 6, 1883. One son was born to this union, Carl August Gauss, April 10, 1849, who married Anna Ebmeier, of Stolzenau. Their eldest son, Dr. Carl Joseph Gauss, born on October 29, 1875, is ordentlicher professor and director of the Women's-Clinic at the University of Würzburg, Bavaria. He is noted for work in the field of X-ray, painless childbirth and twilight sleep. Carl August was the only grandchild of the mathematician living in Germany, and died at his home in Hameln on January 22, 1927; his younger son Wilhelm lived at home with him, and his daughter is the wife of Judge Noeller in Gummersbach.

On November 21, 1807, Gauss and his family settled in Göttingen, where he had accepted the professorship which was to continue as his occupation for the remainder of his life. His second child, Minna Gauss, was born there on February 29, 1808. In 1830 she married the celebrated Orientalist and theologian, George August Heinrich von Ewald; they moved to Tübingen, where Ewald had accepted a position as professor of theology in 1837, and she died there on August 12, 1840, leaving no children. Her death was a severe blow to her father, who loved this daughter deeply; Minna is said to have resembled her father very much in personality. Ewald later returned to Göttingen, married the second time a Miss Schleiermacher, and was survived by her and one daughter, his death occurring on May 4, 1875.

The third child of Gauss was born on September 10, 1809, named Louis, and Frau Johanna died on October 11. The infant died on March 1, 1810, and on April 1, Gauss became engaged to Minna Waldeck, the second and youngest daughter of Councillor Waldeck, a professor in Göttingen University. She had been a close friend of Frau Johanna. There were three children of this marriage:

(1) Eugene, born on July 29, 1811, was educated at the University of Göttingen; he came to America in 1831, enlisted in the army, and was sent to Fort Snelling, Minnesota. At the expiration of his term of enlistment he became connected with the American Fur Company, later settling in St. Charles, Missouri, where he lived for many years. His death occurred on July 4, 1896, at his farm in Boone County, Missouri. He had various business interests, such as lumber, flour milling, etc. On February 14, 1844, he married Henrietta Fawcett (born on February 3, 1817), whose family had moved to Missouri some years before from Rockingham County, Virginia. To this union seven children were born, three of whom are now living. Henrietta Gauss died in November, 1909. Eugene Gauss was a Christian gentleman of high moral character and had intellectual qualities of a type similar to that of his father.

(2) Carl Wilhelm, born on October 23, 1813, in Göttingen; he came to America in 1837, and had married Louisa Aletta Fallenstein, a niece of the astronomer Friedrich Wilhelm Bessel, shortly before sailing from Germany. He stopped at St. Charles for a short time,

GAUSS AT THE OBSERVATORY IN GOTTINGEN

but moved to Glasgow, Missouri, where he engaged in business, later living on a farm near Brunswick, Missouri, but finally locating in St. Louis, in 1855, where he engaged in the wholesale mercantile business up until his death there in 1879. He was a very affectionate man, generous and possessed of splendid spiritual and intellectual powers. Two of his sons are living at present, one in Colorado and one in Missouri.

(3) Theresa, born on June 19, 1816, and died childless on February 11, 1880; after the death of Frau Minna she assumed charge of the household, and with love and tenderness she faithfully cared for her father until his death. In 1856 she married an artist named Constantine Staufenaü, with whom she had corresponded uninterruptedly for fourteen years. They lived in Dresden; Staufenau married again after her death, and his second wife returned in her will the property that had come from the Gauss family.

In 1808 Heinrich Christian Schumacher had come to Göttingen to study mathematics and astronomy; he and Gauss became the warmest of friends and scientific collaborators, their correspondence continuing up to Schumacher's death in December, 1850. In 1810 Gerling, Nicolai, Möbius and Encke came to Göttingen, which became the mathematical mecca of Europe. Needless to say, the fame of this town has rested on the Gauss tradition. He did not allow students to take notes in class on his lectures, for fear they would lose the thread of his argument. These men became very fond of their great teacher and later distinguished themselves in their chosen fields. The students would be seated around the large table in rather informal style, and Gauss would take great care to explain in detail every step in the reasoning—something which a reader does not always find in his published works. On several occasions he complained of lack of ability or of prep-

aration in his pupils, but these occasions are rare. Perhaps his most celebrated pupil was George Friedrich Bernhard Riemann, 1826–1866, the geometer, whose paper Gauss chose from the three themes submitted in 1854 to be read before the Philosophical Faculty. This monograph, "Ueber die Hypothesen welche der Geometrie zu Grunde liegen," immortalized Riemann's name in the discovery of non-euclidean geometry, and, indirectly, reflected to the credit of Gauss, his teacher, who had been meditating on the subject for some years, as we know from his letters and other evidence, although he never published anything on the subject. Riemann succeeded Dirichlet (who was Gauss's successor) in 1859 as professor of mathematics at Göttingen, which position he held until his death. It is said that Gauss often gave his students skillfully contrived mnemonic schemes to enable them to memorize very involved mathematical formulae. As for himself, we know that his genius had no difficulty in such matters, and that he also delighted in long, mental or written, arithmetical calculations, as did his son Eugene; both exhibited the utmost patience.

About 1810 Gauss interested himself in optics and also dioptrics. His results and formulae found practical application after his time. In 1840 he published his "Dioptrische Untersuchungen," and in 1843 he presented before the Royal Society of Göttingen, of which he was director, his "Dioptrische Studien." In 1812 he had published his treatise on hypergeometric series, and among other achievements placed the imaginary on a firm basis.

In 1818 Gauss was commissioned to carry out the triangulation of the kingdom of Hanover, following similar work of his friend Schumacher in Holstein, and later for all Denmark. This work occupied his time rather extensively from 1821 until 1826 and to some extent as late as 1848. This fact was lamented by some writers who felt that too much of his time was taken by trivial and routine matters which could have been handled by one whose time was not so valuable. He was assisted by Major Müller and his son Joseph Gauss. The science of geodesy reached a new point of development through his labors in this field. There were also several rather concrete results of this undertaking. The old geodetic instruments were unsatisfactory, and one afternoon (1821) while Gauss and his son Eugene were walking along, the father, noticing the light of the setting sun reflected from the window-pane of a distant house, thought of the heliotrope; in the simple form, this instrument consists of a plane mirror 4″, 6″ or 8″ in diameter, which may be rotated about a horizontal or a vertical axis. This mirror is at the station to be observed, the sun's rays reflected by it impinging on the distant observing telescope. The heliotrope is used in geodesy for observing stations that are far removed from each other, is pleasant to operate, and to the observer it appears to be a star of the first or second magnitude.

In July, 1821, Gauss measured with this instrument the classic geodetic triangle; Hohenhagen, Brocken and Inselberg. To-day there is a lofty Gauss-tower on the Hohenhagen to commemorate the work of this scientist. In it there is a splendid marble bust of Gauss by the late Professor Gustav Eberlein, a Gauss-stone or marker which he used in his geodetic observations there, and also the first heliotrope. It is interesting to note that William II, as Kaiser, gave 4,000 marks toward the building of this tower. As final results of the geodetic work, we may consider "Disquisitiones generales circa superficies curvas" (1827) and the two "Abhandlungen über Gegenstände der höheren Geodäsie" (1843, 1846).

CARL FRIEDRICH GAUSS

In the summer of 1831 Gauss had begun to study crystallography, but this subject did not make a great appeal to him, notwithstanding the fact that he made some valuable contributions to the science. At a scientific meeting in Berlin in 1828 he had met the young physicist, Wilhelm Eduard Weber, who, in 1831, accepted the professorship at Göttingen. Both were devoted to their own subjects, and they complemented each other. They collaborated in 1833 in producing the electro-magnetic telegraph, the signals being given by the deflection of a galvanometer needle. The wires extended from the observatory to the steeple of St. John's, and from there to Weber's physics laboratory. The inhabitants of Göttingen saw Wilhelm Gauss helping his father and Weber string up the wires over the house-tops, and upon their learning that it was to carry an electrical current, they became excited, so that Weber had to write to the magistrate to explain the purpose. The line was destroyed by lightning in 1845. It is beyond the projected scope of this article to describe in detail the telegraph which they used, but is sufficient to say that they devised an alphabet, and could send messages accurately, with a speed of about seven or eight words a minute, by using an induced current. Germany has always been proud of these two men for such an early achievement. Gauss lived to see some of the development of telegraphy, and always took great pleasure in noting it. His system was readily applied by Lord Kelvin to ocean telegraphy. The last letter of Gauss, written to Sir David Brewster, was about the early telegraph.

It is significant to note that both Gauss and Morse attached military importance to the telegraph. The former, in a letter to Schumacher, mentions the fact that the Russian czar might transmit his orders immediately from Petrograd to Odessa; Morse wrote a letter to the new republic of Texas, offering the government his recent invention of the telegraph, pointing out the military advan-

GAUSS AND WEBER

tages of such a contrivance. It was, of course, not accepted.

Gauss and Weber investigated the science of magnetism very thoroughly, and laid the foundation for the modern study of it. They formulated fundamental laws and theories in this field. Two magnetic units are named in their honor. Through their efforts and the efforts of Humboldt were established observatories for terrestrial magnetism. Gauss invented the bifilar magnetometer which is used to measure changes of horizontal force; in the mechanical constructions he was ably assisted by Johann von Lamont, a Scotch Jesuit, then living in Germany. Regular magnetic observations were started in 1834; already in 1833 Gauss had published his "Intensitas vis magneticae terrestris ad mensuram absolutam revocata." Together with Weber he published in 1840 an "Atlas des Erdmagnetismus"; then came the important "Resultate aus den Beobachtungen des magnetischen Vereins" (1837–1843).

On April 18, 1839, Frau Dorothea Gauss, the mother of Carl Friedrich, died; she had always been very proud of her only son, and he showed the greatest affection for her. She had become blind several years before death, but this did not stop her usual activity. Gauss was an excellent father to his family; he loved social intercourse and conversation; in his home he was always glad whenever the simple meal was accompanied by some discussion or poetic subject. In the family nothing was too unimportant; for instance, he kept in a note book the dates when his children cut their teeth, and he kept a register of all the keys to the rooms of his observatory and his home. He was very fond of music, especially singing. Whenever he heard a beautiful song he would go and write it down. Frequently he played whist. He had a subtle, keen sense of humor which might manifest itself in friendly satire. In his later days Gauss would go daily to the so-called literary museum to consult the many newspapers there, where he was known as a *Tiger for News*. What interested him especially was political and financial news. He was always solicitous about the welfare of his country, particularly during the Revolution of 1848, probably because he thought back to his experiences during the Napoleonic wars; he used to say, "Mundus vult decipi." Gauss knew how to invest his money well, unlike many men of science, leaving a large estate at his death. It is said that the czar of Russia once offered him a post as minister of finance, and also that he once refused an offer of a title of nobility. He never wore any of the many decorations which the different governments had showered on him. His daughter Theresa, in a letter on the celebration of his fifty years' doctorial jubilee, bewails the fact that none of his beloved sons could be with him on his day of triumph.

Gauss did not like to travel, and from 1828 (his trip to Berlin) until his death, only once did he spend a night away from the observatory, it being in 1854 when he attended the opening of a railroad and saw a locomotive for the first time.

About 1840 he studied Sanskrit, but only for a short while. He was acquainted with the modern European languages and could speak many of them. In his sixty-second year he took up the study of Russian, and in two years he had mastered it completely, being able to speak it and to do his correspondence to Russia in the native tongue. He had probably been urged to do this by a desire to read Lobachevsky's work on non-euclidean geometry in the original. He read English often, in his last days completing Gibbon's "Decline and Fall of the Roman Empire," and the works of Sir Walter Scott, which he greatly admired.

Gauss considered all philosophical

GAUSS–WEBER MONUMENT IN GOTTINGEN

ideas as subjective; he was possessed of great religious tolerance, which must not be confused with indifference. He also held that one is not justified in disturbing another's religious belief, in which they find consolation for earthly sorrows in time of trouble. The striving after truth and righteousness were the foundations of Gauss's religion. He believed firmly in the immortality of the spiritual individuality, in a personal permanence after death, in a last order of things, in an eternal, righteous, omniscient and omnipotent God. In his own life he exemplified these teachings, being a man of great generosity, kindness and meekness of spirit. His neighbors applied to him the phrase: "Modest and simple, but worthy and strong."

Gauss had excellent health, a strong constitution, had never been seriously ill, but in the last two years of his life he suffered from insomnia and several other ailments of old age. At last dropsy and heart failure developed, and he died on February 23, 1855, surrounded by relatives and friends. On the morning of the 26th, amid a large gathering of students, friends, townspeople, relatives and officials, his funeral was held; Sartorius Wolfgang von Waltershausen, his close friend, and Ewald, his son-in-law, delivered the funeral sermons, and after several hymns, including one of Luther's, and the chaplain's benediction, he was laid to rest in the old churchyard near the Albanitor in Göttingen. The one word GAUSS is engraved on his tombstone, which is unpretentious and plain —in keeping with the character of the noble man. It is a fact interesting to psychologists that R. Wagner studied the brain of Gauss, and found its weight to be 1,492 grams, and the cerebral area equal to 219,588 square centimeters, in whose highly developed convolutions perhaps lies the explanation of his genius.

After his death this powerful mathematician was widely honored. There may be mentioned the Schaper monument in the park on the Gaussberge in Brunswick, his birthplace, and the Gauss Bridge in that city. Many streets have been named for him. In Göttingen, there is the Gauss-Weber monument, by Professor Hartzer, in honor of their invention of the telegraph. On the Potsdam bridge in Berlin, beside Siemens, Helmholtz and Röntgen, stands a masterful monument of Gauss by Professor Janesch, who has also made for the Royal Agricultural Ministry in Berlin a marble bust of Gauss. Another bust is in the Main-Hall (library) of the University of Göttingen. The ship which made the South Polar expedition in 1901–1903, under Professor von Drigalski, received the name Gauss. His centenary was widely celebrated in Germany, many memorial addresses having been published on April 30, 1877. At the present time, a *Festschrift* is to be published in Brunswick on the occasion of the sesquicentennial of his birth.

After the death of his mother, Gauss had not been in frequent correspondence with his brother George Heinrich, who early in life had been afflicted with severe eye trouble. He had become a member of the artillery, which was then composed of the children of the upper class, more than other branches of the army, and so received better treatment. Outside the service, which allowed much freedom—he had to assist his father in his work. Under these circumstances there could not be much hope of promotion, and so after the catastrophe of 1806, he went back home to continue his father's gardening and casket-making. George Heinrich died in his eighty-sixth year, on August 7, 1854, and Carl Friedrich wrote the following rather touching letter to his nephew Gebhard:

I received the sad tidings of your letter of the eighth with heartfelt sympathy. It was grievous for me that for several years I had

remained without any news of my brother. As long as Professor Goldschmidt lived, I was always in touch with Brunswick, because he was accustomed to journey there twice a year to his father who was then still living, and then always made inquiry about the conditions of my brother, and communicated it to me. But Professor Goldschmidt has been dead now for several years, just as all the friends of my youth there. It is the lot of humanity, when one gets old. I am already in my seventy-eighth year, but I will not equal my brother, because I have been feeling the diminishing of my strength for a year. I am unusually glad that I must infer from your letter that the last years of my brother's life were alleviated, as much as the course of events allowed, by the loyal care of your mother, to whom I ask you to convey my heartfelt condolences and greetings.

For thirty-three years I have not seen my native city, and even then for just one day. Now the journey is considerably shortened by the train, because one can come there from here via Hildesheim or Hanover in six or seven hours now, and I suppose in one or two years, when the side-line is opened, in half the time. Whether I will survive until that moment, or whether my strength will permit me to make use of the train, in order to see my native city just once again, is questionable. But it always remains my sincere wish that everything may be well with you and yours.

Within six months Gauss himself was no longer among the living. The following letter of his physician, Dr. Baum, who attended him with unremitting care, written to Humboldt, is interesting in that it gives us a glimpse of the last days of the celebrated mathematician:

GÖTTINGEN, MAY 28, 1855.

Your Excellency:

If I had been obliged to prepare you for the sad news before the death of our great mathematician, the news, which is now the more unexpected, struck the more painfully for that reason: but I was at that time so completely claimed by the medical care of the venerable man, who in his last months saw only his daughter and me around him, besides the many duties of my vocation, that I therefore ask for indulgence.

As we were talking in the presence of Professor Dirichlet, whom we now call our own with happy pride, a great deal about the last conversations of Mr. Gauss, he urged me to communicate to Your Excellency that Gauss at the last often thought of you, and with much love. Your last letter made him especially happy and he read it repeatedly and let me read it aloud. When he was once taken unawares by the apprehension that a more advanced old age might bring to him aggravated complaints, he said: "then the thought of *my* Humboldt consoles me"—an epithet which I have heard him apply to no other name. With joy he believed he recognized your hand in the translation of Arago's Works, where the number of those men is mentioned to whom a final judgment belongs regarding exact experiments: the number in the original is given at about ten, in the translation at about eight: he thought that this diminution, which suited him exactly, could have proceeded only from Your Excellency.

The last days of his life were often very painful owing to the aggravated complaint of dropsy, which the hypertrophy of his heart produced—but still he always maintained his freedom and greatness of spirit, the strongest conviction of his personal permanence, the firmest hope in the still deeper intelligent insight into the number-relationships, which God places in matter and which he would perhaps be able to recognize in the intensive magnitudes, for he used to say 'ο θεος' αριθμετιζει. (God arithmetizes.)

Thus he remained consistent up to the end, so that even in the last weeks he read through the Book *eritis sicut deus*, not without vexation, "for the people would be speaking about things, all means of judging which they lacked,": but he put an end to it nevertheless, although he thought it once made a sleepless night for him.

Only in the last eighteen hours did consciousness leave him, only now and then did it come back for a short time for an utterance of love or for a desire—then silently he slept away.

May these few words be not disagreeable to Your Excellency, these words, which I wrote in the most respectful and grateful love, in which I remain even to the end

Your Excellency's most truly devoted

BAUM.

The following words inscribed under the portrait of Gauss in the Munich Museum best summarize the work of this scientist:

Sein Geist drang in die tiefsten Geheimnisse der Zahl, des Raumes, und der Natur;
Er mass den Lauf der Gestirne, die Gestalt und die Kräfte der Erde;
Die Entwickelung der mathematischen Wissenschaft eines kommenden, Jahrhunderts trug er in sich.

CRIME AND PUNISHMENT[1]

CAUSES AND MECHANISMS OF PREVALENT CRIMES

By the Honorable WILLIAM McADOO

CHIEF CITY MAGISTRATE, NEW YORK, N. Y.

WE are confronted in this country for some time past and at present by an army of outlaws, young fellows, mostly between the ages of sixteen and twenty-six. They are the gunmen and those who commit crimes of violence, aided by pistols, which are as common in the United States as lead pencils, and the speedy motor cars as the mechanisms of prevalent crimes. The large majority of these fellows are lacking in the normal emotions of love, sympathy, kindness, gratitude, friendship and a sense of civic obligation, but on the contrary they are cruel, cowardly, heartless, selfish, ungrateful and I may add godless and dangerous, and above all they are determined that they will never do any honest, continuous work. Living in the richest country in the world, in which the sum of a million dollars is talked about as ten thousand dollars would have been some years ago, their idea is to get what they call "easy money" by criminal methods so that they may not have to work and have it to spend on their appetites, lusts, passions and vanities, for they are immensely vain and proud of their criminal records. The money they get by stealing and robbing goes mostly to gamblers and women of their own type, and the balance is spent recklessly in a style of living to which they ordinarily would not be accustomed.

Just now the country is being flooded by opinions from all classes of men and women as to the reasons for the existence of this desperate, cruel and cowardly army. They are attempting to answer the question, what caused these young fellows to adopt deliberately a criminal career instead of becoming useful, industrious and law-abiding citizens. Some of the writers and speakers in the press, the forum and the pulpit seem to believe that it is from poor economic conditions. They say that when these young men do work they are underpaid or they can not find proper employment or that the cost of living is so high that the salaries they would receive for work would not be sufficient to meet their wants; that there is not sufficient employment for all of them; that they have been educated beyond manual labor and they can not find employment as clerks and the like, and also that they are not permitted to learn trades because of the limitations placed upon the number of apprentices by the trade unions.

For many years past, both as police commissioner and for sixteen years as chief city magistrate superintending the work of thirty-seven courts and fifty-seven other magistrates, and through which courts there pass in the year nearly five hundred thousand people as defendants, from spitting on the sidewalk to murder, and having had unusual opportunities for noting conditions, economic, social, political and religious, it is my firm belief that the main trouble with these fellows is that they will never do, as I have said before, any honest, continuous labor. The great majority of them have started out de-

[1] Addresses presented before Section K—Social and Economic Sciences, American Association for the Advancement of Science, Philadelphia, December, 1926.

liberately with their minds made up that they will get easy money by criminal methods, and the pistol makes intimidation and robbery easy and the motor car is at hand for a successful escape after the crime has been perpetrated. It is preferable for them to steal a car and use it on a criminal enterprise rather than one which may have come into their possession legitimately. Unfortunately, in most of our big cities there is a small number of taxicab drivers, who bring disgrace upon the rest of that body by lending themselves and their car for criminal purposes so that they may share in the proceeds of successful robbery. This has brought about a humiliating and astonishing scene here in New York and other big American cities, in that the money taken from and to banks and to industrial concerns is carried about in heavily armored cars and protected by men armed with pistols. A mere suggestion of such a change in the method of delivering money some years ago would have been laughed at as an impracticable and unnecessary means of transferring large sums of money. Our banks have to be guarded by armed men as in time of serious, civil disturbance.

Recently, as a sample of the times in which we live, a man, himself a gambler and a bootlegger, went into a place where they were playing a game of craps or dice-throwing for very large sums of money. He won $50,000, which was offered to him in cash. With a significant look around the room at the crowd present he handed it back to the dealer and said, "I am not foolish enough to undertake to walk out of this place with that amount of money. I will take a check."

Other writers and speakers are insisting that these young fellows are the victims of heredity and environment, products of congested tenement houses, pedigree-marked by elements of physical, moral and spiritual decadence, drunken, coarse-living, vicious and immoral parents. Others insist that these soldiers of crime are to be sympathized with and kindly treated and reformed.

In this country no young fellow who wants to work need go idle, and the wages are the highest in the world in all classes of employment, so there is no economic distress which would force recruits into this murderous army. It may, therefore, I think, be safely concluded that my assertion that they will not work is absolutely grounded in fact. They are lazy loafers and will continue to be so once they are started on a criminal career. They will rob, steal, swindle, terrify, sponge on their parents, rob their own family, sell narcotic drugs, tout for racetrack bookmakers, and in some instances and in certain localities terrorize and blackmail the whole neighborhood through fear of them. I am sorry to say that I do not think that the large majority of them are reformable under any conditions. Can psychiatry and psychology actually tell us how far heredity and environment are responsible for them? Can we analyze the character of a Gerald Chapman, Whittemore and "Bum" Rodgers by ascertaining their mental ability or lack of it? Science can only tell me as to the fellow's head. It will leave me groping in the dark as to his character. I want to know about his outlook on life and his personality. How, otherwise, is it that of large families, say five or six young men, only one will turn out to be a "black-sheep"? How is it that the other five born in a congested tenement house in an undesirable locality, of the same parents, do not go wrong and are in all respects good citizens. Of course, I understand that we all have different finger-prints and it is a matter of common observation that members of families are different, radically so in temperament, spirituality, morality, industry and very much so in physical appearance.

I am not underrating these new sciences. On the contrary, I believe that they should be used freely in our courts and custodial institutions, and I would like to see them able to give us an analytical biography of the subject by which we could look into the heart of the man as well as his head. Some of the most notorious crooks and criminals have been extraordinarily smart fellows and I have no doubt would pass good mental examinations, but it is a peculiar bent of character and personality that we should inquire into. Possibly the aftermath of the great war and the immense wealth of this country has something to do with the psychological atmosphere, which we might so term it, in which these fellows exist and which brought them forth. I regret to say that it is my opinion, from experience, that of the large majority of pickpockets, for instance, who pass through the magistrates' courts, most of them will continue picking pockets as long as they are alive. When we give one of them six months in the workhouse, it is with the satisfaction that during those months he will not be able to pick the handbags of hardworking women or the pockets of comparatively poor men in public conveyances. When they get out they will go on picking pockets again. Giving that type of pickpocket and gunman six months or six years is simply beneficial to the community in keeping him from criminal activities during the period for which he has been sentenced. It will not reform him, whether he gets six years, twenty years or life, nor can we make salvage of any very considerable percentage of this type of criminal. If we save from 5 to 10 per cent. we are doing extraordinarily well.

My own idea for many years past is that in this state we will eventually have to create a great custodial institution, which will neither be a state's prison, penitentiary, a jail or a reformatory, but will be a self-supporting community with farms, shops, churches, schools and every other feature of modern progress. To this custodial institution will be committed the type of fellows that I am talking about. They will be given an indeterminate sentence with a substantial minimum, during which period they will be under constant observation of experts, experienced men and women, physicians, psychologists, psychiatrists, and live their lives in a mental, moral and spiritual atmosphere in the hopes that they can be reclaimed. They will not be discharged until they are pronounced, as it were, cured, and the community will have the assurance of those in charge of them that they are no longer dangerous and a menace, that this young fellow, who has been a gunman, and the other young fellow, who has been a pickpocket, have really been regenerated, remade, reclaimed and can be safely turned back to the community without danger to it.

How many of them will be turned back? I do not know. As I said before, there might be hopes of saving a percentage of them. As it is now they go in and out of jails, workhouses, penitentiaries and state's prisons until they get long, criminal police records and the very fewest number of them are ever shown to have been reformed by the deterrent effect of the present treatment.

We will get nowhere with a sloppy sentimentalism on the one hand or a ruthless inhumanity on the other.

My own idea of a prison is that its chief use at present is that it keeps the dangerous element of crooks, criminals, gunmen, swindlers and pickpockets from practicing their arts for the time they are in prison, and I do not believe that they would be reformed or deterred in any way on their release by the fact that they were subject to the old, harsh, cruel methods that used to prevail in the old-fashioned prisons.

The pistol is the curse of America, and they are almost as plentiful as lead pencils in this country, good citizens and

bad citizens possessing them. This is the greatest market for the sale of pistols in the world. In addition to our own manufacturers, those imported from Europe include the output from factories in Spain, whose total output of these murderous weapons finds its way to this market.

There are more people shot to death or wounded by pistols in the United States in one year than in all the rest of the world besides. The pistol is not a sporting weapon. It is intended to kill or maim human beings, or by intimidation to rob them when in the hands of bandits and outlaws.

There are more armed young fellows in the United States between the ages of sixteen and twenty-six whose aim is to get easy money through the pistol and the motor car than in all the rest of the world.

Numerous fortunes are made by the mail order agencies and houses selling pistols. One man here confessed to the police that he had made $400,000 in two years sending pistols through the mails. Pistols can be bought as cheaply as $5.00 apiece or less. Down in Texas and some other states, the Negroes rent the pistols and pay for them on the installment plan. They call it "renting a gun" and most of them who go to the penitentiary reach there by the pistol route.

Recently, there were 500,000 people on strike in England, and not one shot was fired during the whole period of the strike which continued for months. Of the twenty-two thousand policemen in London not one carries a pistol and the criminal classes are not armed; hence they only had fifteen murders in 1924 as against a terrible list in all our cities and even small towns and villages.

We have no accurate statistical information in the United States as to the total number of crimes as given in our police department reports for various cities, large and small. The London police report, under the heading "number of crimes known to the police," gives the total number of reported and ascertained crimes and in the next column the total number of arrests, that is, they may charge themselves with housebreaking and stealing—1,940 such crimes and only 158 arrests; attempts at murder—23, arrests 11; robbery and assault with intent to rob—42, arrests 36, etc., etc. If this rule were followed by the police of all our large American ciites we would know more than we do now as to the total number of crimes. As murders, however, can not be concealed we may rightfully assume that the official reports give the total number, but that does not cover murderous assaults and other crimes.

The pistol manufacturers, dealers, importers and mail order people are represented in all our capitals, both state and national, by one of the most efficient, best organized and cleverly managed lobbies connected with any other business enterprise. They flood the country with specious and easily answered arguments in favor of pistols. Among other things, they are constantly reiterating that under such laws as the Sullivan Act in New York state and other states only crooks, murderers, robbers and dangerous criminals can get guns, which of course is not true, because any decent, orderly citizen, if he shows good cause, can get a permit here in New York to carry a pistol or have one in his house, and all our banks are thoroughly armed with pistol-bearing employees. If this statement of the pistol people were true, then how do they account for the immense number of pistols that flood this country from end to end? Ascertain the number of pistols manufactured in this country; estimate the number imported every year, and we are asked to believe that only crooks and dangerous gunmen get these guns. Well, if that is true, then there must be from 50 to 75 per cent. of the whole population of the United States that are outlaws, criminals and dangerous gunmen carrying guns,

because the argument leads us to suppose that honest, law-abiding people are disarmed.

All the literature and advertising for pistols seems to be based upon an assumption which is purely illusory and invented in fact. I assert and I have done so for years past and will continue to do so so long as the facts bear it out, and that is this, that the pistol as a defensive weapon is utterly and positively useless in the hands of a law-abiding, orderly citizen because of the element of surprise on the part of the robber, burglar or assassin. I have been held up, and if I had a dozen pistols they would have been useless. Time and time again bank messengers, loaded with pistols, have been shot down by robbers who had carefully planned the attack, surprised them when they least expected it and robbed them. Hundreds of homes have been robbed and burglarized where the owners had pistols. If I am going to hold you up, rob you, burglarize your house or assassinate you, I will have planned it all out carefully beforehand; the whole operation would be strategically considered; you have gone days, months and years without such an attack and you will not be expecting it at the moment when it is thrust upon you. The robbery, the assault and the murder are the unlooked-for things. Carrying pistols or dozens of them is no defense against such happenings.

No one has a constitutional right to carry a concealed weapon like a pistol. Any citizen can go all over this country, including New York state, with a rifle on one shoulder and a shotgun on the other and there is no law to interfere with them.

I could give tables of various American cities, such as New York, Boston, Chicago, San Francisco, New Orleans, in fact all of our cities as against the great cities in Europe, and the comparison is a national disgrace and humiliating as to the shooting and killing records.

I would as soon place a full-venomed, cobra snake in my house as a loaded revolver. Look at the tragedies in the morning newspapers, where husband shoots wife, man shoots mistress, one child shot the other, frenzied head of the family kills the whole family and himself, until all over the country it is bang! bang! bang! every hour of the day and night.

It will take some time to educate public opinion, but when it has received knowledge of the actual facts, it is my belief that the pistol will have to go, and I hope to see the time when a person possessing, owning or carrying a pistol will lose his or her character as a law-abiding and respectable citizen. When we have convinced people to throw away these murderous weapons, we will then only have to deal with the armed, dangerous professional criminal type, and if we make the purchase and procurement difficult or impossible, and the police authorities do their duty, the battle for law, order and personal and communal security will have been won.

There is an excellent bill now pending in the New York legislature which will reach the pistol at its source, in the factory and in the custom house, and when I say the factory that also will of course include those who make the cartridges. Unfortunately, under the federal constitution a law taxing cartridges, say at one or two dollars apiece and only allowing them to be sold to peace officers in the Army and Navy, might be considered unconstitutional as an attempt on the part of the government to secure police powers by way of taxation. A bill taxing pistols and ammunition for the same was introduced a year or two ago by Senator Copeland, of New York. The bill was drawn by myself and Professor Chamberlain, of Columbia University, but under recent decisions of the United States Supreme Court the bill seems to be open to constitutional objection. I say this because whenever any good bill

appears in any state legislature, the opposition very cleverly get up and say that it should be postponed and we should look only for relief to Washington. As a matter of fact an excellent bill called the Miller Bill, taking the pistols out of the mails, passed by the House of Representatives at the last session, has been favorably reported by the Committee of Finance in the Senate and is now up for action, but every time it comes up somebody opposes it, possibly in the hope it will go over until the 4th of March, thus necessitating its repassage through both houses before it can become a law. Some of the arguments used against this bill a few days ago in the United States Senate were to the effect that the Sullivan Law was ineffective here in New York. In reply to that I wrote to one of the Washington newspapers as follows:

> The Sullivan Law, in spite of the handicaps pointed out in your editorial, is so very effective here that if it were repealed the crime wave would be immensely increased and the police arm of government tremendously handicapped and conditions generally would be inexpressibly bad. As it is now, and I am quite sure Commissioner McLaughlin will agree with me, the Sullivan Act is the most powerful weapon that the police have in dealing with dangerous criminals, of which we in common with all other American cities have too many.
>
> As you say in your editorial we have been handicapped by the fact that New Jersey has not as stringent a law as that known as the Sullivan Act, although that state is fully alive to the situation and at the last session of their legislature amendments were made to the existing law in tending to break up what had been an open market for pistols on the west bank of the Hudson River; but most of all we suffer from flooding this city with pistols by mail, and from here unconscionable rascals send pistols all over the country through the mails.

Since writing the above I saw a statement in the morning newspaper to the effect that the Boston commission investigating these crimes attributes the criminal actions of these young men to the use of "bootleg" liquor. I do not of course know what is happening in Boston, but so far as New York is concerned the gunmen, the loft burglars and the pickpockets do not drink alcoholic liquors, certainly not to excess and they never have. If they were tipplers and drunkards as outlined in Boston, their capture would be easy and they would not be able to carry out the well planned crimes that now take place. I repeat again the clever criminals are not now and never have been drunkards. I believe, however, from the facts and data at hand that a good many of them are drug addicts and under the influence of the drug their senses are even more acute than when they are without it, in fact I have had before me addicts who work in the most perilous sort of employment, as constructors on huge steel edifices going up to forty stories and horse jockeys and others who engage in extraordinarily hazardous employment and who are constantly under the influence of narcotic drugs while so employed.

CRIME IN THE COMMERCIAL FIELD

By Professor JOSEPH MAYER

TUFTS COLLEGE

In these days we hear much from the public press regarding a crime wave and the establishment of crime commissions to look into the matter. "The responsibility," as George D. Nathan very well expresses it in the *American Mercury* for February, 1926, "has been placed upon everything from the late war to the modern novel; from Bolshevism to bad booze; and from insufficient police protection to the automobile and the easy means of escape provided by the latter." There can be no question that there is considerable crime in the coun-

try. But the causal factors are quite different from those ordinarily assessed and a long range view of the situation from the Civil War period to the present day demonstrates that, comparatively speaking, there is no more crime now than there always has been here. That is to say, taking population increase into consideration and taking into consideration also the fact that there is a flaring up of criminal activity at one time and more of a subsidence at another, the proportion of criminals to population has not shown any marked change. The fact is that in the United States—a new country, a frontier country and a country in which police espionage and systematic registration of citizens would not be tolerated—there has always been more crime than in older nations in which everybody is under surveillance from the time he is born to the hour of his death.

In the commercial field, however, there has recently been in America an enormous increase in crime. Here again the actual causal factors are other than those usually given. In the opinion of William B. Joyce, chairman of the National Surety Company—a man who has made a long study of embezzlement, forgery, stock swindling and insurance and credit frauds—the principal cause of the increase in commercial crime in this country is the enormous increase in the volume of American business. Mr. Joyce simply expresses the conviction of most authorities. Here as elsewhere in the field of crime, it is not so much a question of criminal types as it is a question of temptation and opportunity.

Let us for a moment consider how vast has been the industrial development of America in recent years. In the last decade the wealth of the United States has almost doubled. It is now placed at $300,000,000,000. Several details of this development may be given as illustrative. Out of comparative insignificance fifty years ago the American money market has risen to first place in international affairs. Our railroads bring in a daily revenue of approximately twenty million dollars. Our telegraph lines carry seven million messages every twenty-four hours. In the same period there are seventy-two million telephone calls, $1,500,000,000 in bank clearings and six million dollars of imports at a single American port of entry. All these and other increases in the business activities of the nation have made possible the operations of commercial crime on a scale hitherto unheard of in the history of the world. Methods of protection against dishonesty in business have simply not kept pace with our industrial expansion.

That the economic and financial loss involved in criminal activities in the commercial field is considerable will readily be conceded. The exact extent of the annual loss can not, of course, be accurately computed. However, authorities are fairly well agreed that a figure somewhere between two thousand and ten thousand millions represents it. If we take the higher figure of this estimate, our commercial crime cost is three times as much as is now appropriated each year for the running expenses of our government and represents 15 per cent. of the total annual national income. It is just about equal to the sum total of the war debts owed to the United States as a result of the late war. William J. Burns, former head of the Bureau of Investigation of the Department of Justice, and Mr. James E. Baum, manager of the protective department of the American Bankers Association, are practically agreed on setting the present yearly loss due to commercial crime at something like four thousand millions. The following table prepared by Mr. Baum indicates the major categories of crime in the business field and the annual losses involved.

Recent Annual Loss due to Commercial Crime. (Figures for 1924)

Stock frauds	$1,700,000,000
Tax and insurance frauds	1,000,000,000
Credit frauds	400,000,000
Burglary, larceny, petty thefts	250,000,000
Embezzlement	120,000,000
Seaport robberies and railroad thefts	125,000,000
Forgery	100,000,000
Arson	50,000,000
Miscellaneous	75,000,000
Total	$3,820,000,000

We have not the time here to develop at length the ramifications of each of the items on this list. Only a few can be touched upon. With respect to the first item, namely, stock frauds, in which the enormous sum of $1,700,000,000 is involved each year, there are many interesting details of operation and law enforcement. Millions upon millions of dollars are squandered annually on worthless promotion schemes developed with deliberate intent to deceive and defraud. Oil promotion ventures have lent themselves especially to fraudulent practices. During the years 1918 and 1919 the United States Treasury Department estimated that approximately four hundred million dollars worth of Liberty Bonds were turned over by their holders in return for various forms of fraudulent securities.

Every successful new invention, such as the automobile or the radio, is immediately seized upon by a swarm of crooked professional promoters, who take advantage of newly aroused public interest to unload worthless stock. This form of fraud invades every phase of business life and thrives on the credulity of the average person. The outward forms adopted by swindlers to camouflage their operations are continually changing. One year the public is induced to sink its savings in new oil wells or in foreign exchange trading; another year in land speculation, as in Florida real estate, or in wildcat mining ventures, or in security and commodity bucket shop operations will be the forms in vogue. Stock frauds grow stronger each year, nor is there any phase of commercial crime which is more difficult to handle through established law enforcement agencies. Security swindlers devise clever methods for covering up their operations and the victims are often reluctant to make known the fact that they have been fleeced.

Credit frauds represent an interesting and complicated category. Under it are included the making of false financial statements, concealment of assets or wrong disposition of assets and the destruction of books of account. Ordinarily three steps in the development of such frauds can be traced: (a) Misrepresentation, (b) diversion of assets, (c) bankruptcy. Misrepresentation as here used takes many forms. For example: Concealment of one or more of the asset items; under-statement or omission of some of the liability items; fraudulent use of the name and credit of another individual or firm; development of a legitimate line of credit for the purpose of later obtaining additional credit for fraudulent purposes.

Arson or incendiarism deserves special mention because it is a most serious menace to society, threatening not only property but life itself. It has been estimated that nearly 50 per cent. of the loss by fire is due to arson—burning property to defraud. During 1924, the fire loss given by T. Alfred Fleming, of the National Board of Fire Underwriters of New York, was approximately $549,000,000, of which $220,000,000 was due to incendiarism.

The crime of arson is largely localized in a few cities and in a few sections of such cities because of the exceptional opportunities offered by the presence of a certain type of broker and public adjuster not found elsewhere. It is one of the most difficult crimes to detect, in that the evidence is usually destroyed by the fire. Arson has become a profession. It

is closely allied to fraudulent bankruptcies and other forms of commercial crime. During the deflation period following the war it has shown a marked increase.

Probably the worst arson situation exists in those lines of industry that are affected by fashion—clothing, shoes and hats—particularly women's wear. The profit in these industries is great, provided the goods can be sold while in style. But if a change in fashion or a miscalculation leaves the goods on a manufacturer's shelves, the loss is equally great, for honest disposition can only be made at a price which does not pay for cost of materials and labor. A fire readily wipes out the old stock, the insurance company settles the claim, and the arson criminal can start in business anew. The fire hazard in the New York clothing industry is so great that some fire insurance companies refuse insurance there. This obviously is an injustice to the honest business man, but under the circumstances it is the only course the fire underwriters can pursue.

The miscellaneous group of the foregoing table contains some important subdivisions such as: counterfeiting of trade names used to identify products; using or furnishing to others without the owner's consent the names of customers or subscribers; obtaining money or property by means of bad checks; giving, offering or promising to an agent or employe gratuities, without the knowledge and consent of his principal, with intent to influence his action in relation to his employer's business; and conspiracy by two or more persons to defraud another of property or prevent another from exercising a lawful trade.

Commercial crime, whether it involves two, four or ten billions annually in the United States, is a staggering problem—one that should compel the serious attention of every fair-minded citizen. Nor have efforts to solve it been lacking. The federal government, the states and private organizations have been busy for some time attempting to curb the evil, and their efforts have not been without some success. In 1922 the attorney-general of the United States announced that 480 cases of commercial fraud were pending in the federal courts at the time and that illegal transactions involving a daily average of $2,000,000 were being brought to the bar of justice. The Post Office Department, at the beginning of the Coolidge administration, finding that approximately 80 per cent. of fraudulent securities were being disposed of through the mails, began a nation-wide campaign to stop the practice. The effect has been noteworthy and has succeeded in curtailing the operations of some notorious rings of criminals, as in the recent indictment in Texas of ninety-two individuals who during five years had cheated two million investors out of $140,000,000. Additional appropriations are needed to follow up this excellent beginning. No more profitable way could be found for utilizing the taxpayers' money.

The states have also been busy endeavoring to cope with the problem, some forty of them now possessing blue-sky legislation, the purpose of which is, as the name implies, to prevent the sale of patches of the firmament. By providing commissions of investigation and supervision, information regarding legitimate ventures and actually regulating the issue of securities (as in Illinois), further curtailment of fraudulent operations has resulted.

But there is still little uniformity in these laws; at best they attack only one form of commercial crime; swindlers quickly ascertain in which states there are no such laws or wholly inadequate ones and concentrate their efforts there; and legitimate business has often been interfered with by ill-considered provisions. In short, only a beginning has been made on the part of the states in grappling with this elusive problem.

Private agencies have also been active. The Associated Advertising Clubs of the World have been giving widespread publicity to certain types of fraudulent business practices. The Investment Bankers Association, the Better Business Bureau of New York and the New York Stock Exchange, especially the latter, have instituted vigorous campaigns against financial swindles and bucket shops. The Stock Exchange has of late years followed a consistent policy in refusing the use of its facilities for questionable ventures and in encouraging a high business morality among its members.

Federal, state and private agencies are in one way or another endeavoring to reduce the activities of the commercial criminal, and yet his activities continue with little apparent abatement. What are the reasons for the inadequacy of attempted checks? Why are these efforts not more effective? The answer falls into four categories, the first, already mentioned, centering in the fact that the expansion of business enterprise has been so rapid in recent years in America that it has simply been impossible as yet for instrumentalities of crime prevention to be perfected to keep pace. The other three comprehend the lack of cooperation between preventive and corrective agencies, the crying need of better law enforcement facilities all along the line and an appalling lack of interest on the part of the average citizen.

From the standpoint of better cooperation among corrective agencies, it would seem that the time has come for the federal government to take drastic action, not merely in the Post Office Department or in the Department of Justice, but through some agency with sufficient funds and experts to give the major part of its attention to commercial crime. The Federal Trade Commission was organized to correct certain questionable business practices. Opposition to its efforts has come from those who do not wish their methods to be bared to the light of day. There has been talk of abolishing the commission. Never was it more needed than at the present time. Furthermore, its powers should be extended or another agency created to ferret out what has already been labelled as criminal in commercial dealings. Such a federal bureau, in cooperation with the states, private agencies and the courts, should go far to bring the commercial crime situation under control.

As for law enforcement, Gladstone long ago said that "the object of government should be to make it easy to do right and hard to do wrong." Where, despite the law, it is easy to do wrong and evade punishment because of inadequate enforcement machinery, little progress in crime prevention is to be expected. As far back as 1908, Chief Justice Taft, in an address before the Civic Forum of New York City, said:

> The administration of criminal law in this country is a disgrace to our civilization. The prevalence of crime and fraud, which here is greatly in excess of that in European countries, is due largely to the failure of the law and its administration to bring criminals to justice. As murders are on the increase, so are all offenses of the felony class; and there can be no doubt that they will continue to increase unless the criminal laws are enforced with more certainty, more uniformity, and more severity than they are now.

What was true in 1908 in this respect is even more true to-day. Law enforcement in the United States is in many respects an absolute farce. And that condition has existed long before and still exists quite apart from the Volstead Act. Court delays and postponements encourage crime. "Because sentence against evil work is not executed speedily," warned the Old Testament prophet, "therefore the heart of the sons of men is fully set in them to do wrong." The lapse of many centuries has not changed in one iota the truth of that statement.

Laxity in law enforcement is reflected by the public attitude. A wider respect for law on the part of the average citi-

zen is a crying need. Better law enforcement and a higher moral tone must be developed hand in hand. In fact, F. Truble Davison, chairman of the National Crime Commission, maintains that "when public opinion becomes sufficiently aroused, the drive against crime will become effective." The commission has dedicated itself "to stimulate public interest and action in the restoration of respect for the authority of the state, in the performance of its fundamental duty of protecting the persons and property of its citizens." As yet the effect upon public opinion has not been encouraging. Instead of more introspection, the result has been in the main a denunciation of exceptionally daring or notorious criminals and the working up of a crime-wave scare. What is necessary is a looking inward on the part of every resident of this country, man, woman and child, and a high resolve—at a time of the year when resolves are in order—that each one will himself be more punctilious in his obedience to law and will frown upon law violations by others. When once the conviction becomes general that the man who endangers the lives of others by deliberately violating traffic regulations or makes it possible for bootleggers to flourish is just as bad at heart as the man who deliberately sets fire to his place of business or sells you worthless securities, there will be less commercial crime, for the moral fiber of the people will then be strong enough effectively to resist it.

Nor is this the millennium to which I am pointing. The American citizen has in many respects already shown himself capable of scrupulous adherence to moral principle. Our intricate credit structure is based upon confidence and good faith. Here we have, together with England, forged far ahead of other nations. Most American business men appreciate the sanctity of contracts and the importance of honesty in business dealings. What is needed to raise the moral tone of America is simply a further extension of these habits. We live in an age that demands this. In the complicated economic organization in which we find ourselves, we must place confidence in our fellows. No one can possess a knowledge of all the facts upon which his economic welfare depends. He must rely upon others. The danger of being victimized is therefore always present. Lack of respect for laws which aim to protect us in our complex social and business relations is a serious menace. Commercial crime, unless brought under control by adequate federal and state action, proper enforcement of law and high moral resolve on the part of every citizen will in the end destroy our civilization. The fraudulent acquisition of from two to ten thousand million dollars annually represents only the financial side of the situation, bad as that is. But the moral and social decay which this colossal flaunting of law and integrity implies strikes at the very heart of our democracy. If a people can not respect and obey the laws of their own making, possibly Lenin and Mussolini are right. Will government of and by the people perish from the earth when our continent becomes as densely populated as Europe and Asia are now and the Malthusian pressure begins to be cumulatively felt here also? Democracy is still on trial despite America's vaunted prosperity. It will be on trial until our people show themselves sportsmen enough to abide by majority decisions, ethical enough to do habitually unto others as they would be done by, and intelligent and vigilant enough to realize that law infractions, no matter how trivial, and condonation of evil-doing must be vigorously combatted by everyone if our institutions are to survive.

LOCAL CRIME COMMISSIONS; THEIR ORIGIN, PURPOSE AND ACCOMPLISHMENTS

By JAMES M. HEPBRON
BALTIMORE, MARYLAND

INTEREST in crime and criminals is not new. The criminal and his deeds have excited popular interest throughout the ages. Folk-lore, poetry, fiction and the drama have had as their theme some crime or the extraordinary conduct of a criminal. This interest, no doubt, is explained to a considerable extent by our interest in the unusual.

In modern times there has been a growing tendency on the part of the public, the press and fiction writers to make heroes of criminals and to depict them as being hounded by the police and subjected to brutal and inhuman treatment in the form of the so-called "third degree." Stories of innocent people unjustly convicted are given widespread publicity and from one such particular case (if true) the public generalizes. The public attitude slowly changed to one of sporting interest in the criminal. Serious crime increased. The public became more apathetic than ever. Encouraged by success criminals became bolder until to-day in at least one American city we have the spectacle of battles being waged between organized gangs of bandits and rival bands. The police and other law enforcement officers, or in fact any one standing in their way, are looked upon as a common enemy.

The average citizen, at last feeling his own sense of personal security endangered, began to demand that something be done to check the criminal element. Bonding and insurance company rates by this time had reached a new high level. Their tabulation of yearly losses reached staggering sums and those losses were naturally passed on to the public in the form of increased premiums. Suddenly the question of crime and the administration of criminal justice became a question of vital importance and of frequent discussion by business, civic and professional organizations. The press by this time was filled with discussions of "the crime problem," "law enforcement," "miscarriage of justice" and "abuse of legal process."

Attention was called to the fact that America is an acknowledged leader in other fields, such as medicine, business administration, engineering and the technical arts; why, then, had America not made similar progress with a problem of equally vital interest to society, the efficient administration of criminal justice?

Once public opinion had been aroused to the growing danger of unchecked criminality, all that was necessary to bring about some form of concerted public action in a given community was a particularly atrocious crime which caused an overwhelming feeling of popular resentment. The Chicago Crime Commission was the outgrowth of just such a situation in 1919.

The Cleveland Association for Criminal Justice came into being in a similar way a short time later. The organization of this association, however, differed in that it was preceded by a most thorough and painstaking survey of the administration of criminal justice in Cleveland, which was directed by Dean Pound and Felix Frankfurter, of Harvard University. The published report of this survey is too well known to need comment.

Baltimore late in 1922 was the next city to organize a crime commission. The creation of the Missouri Association for Criminal Justice followed some time

later and was the first association organized on a state-wide basis. The complete survey made by this association has now been published in book form by the Macmillan Company. It is the most thorough and comprehensive study yet undertaken on a state-wide plan.

In the summer of 1925 the National Crime Commission was organized and proposed to give its major efforts to the task of urging states to attack the problem of major crimes of violence in an intelligent manner and offers its services as a clearing house of information for the use of state and local commissions.

At the present time there are already in existence nine citizens' organizations (exclusive of the National Crime Commission) combatting crime. In addition seven state legislatures and governors have acted to control the increase in crime and eleven state bar associations have inaugurated advance movements to decrease crime.

Let us then next consider how these local crime commissions are organized, what they do and what they hope to accomplish. Inasmuch as the Baltimore Criminal Justice Commission is more or less typical of the local crime commissions and since I am naturally more familiar with its organization and work, my remarks will deal more particularly with this commission. It is first of all an unofficial organization composed of twenty-one of the business, professional and civic organizations of Baltimore. It was organized by the Board of Trade, following a particularly atrocious murder, perpetrated during a daylight hold-up and robbery. This crime aroused and shocked Baltimore's citizenry as no single event before or since that time, with the possible exception of the Baltimore fire in 1904. The people of Baltimore were a unit in demanding the prompt capture, speedy trial and conviction of the guilty felons.

The well-organized criminal element of the city, faced for the first time with a thoroughly aroused public, began tightening its line of defense. Unscrupulous criminal lawyers, alibi, false affidavit and tip-off men, professional bondsmen and even corrupt members of the police department were hard at work.

Several important things happened in quick succession. A carefully planned scheme to thwart the police in the apprehension of the murderers was discovered and as a result Baltimore's most notorious criminal lawyer was convicted of conspiracy to obstruct justice and disbarred. Certain police officials rather closely identified with him were removed. An extra criminal court was opened and the task of clearing a much clogged docket was begun. Several professional bondsmen were convicted of perjury, following which certain new rules regarding the granting of bail were put into effect and rigidly enforced.

An aroused public in "taking stock" of the entire situation decided that something was wrong with the administration of criminal justice in Baltimore. It wanted the facts, and looked to the newly created Baltimore Criminal Justice Commission to supply not only the facts but the solution to the problem as well. First of all the public wanted to know just how much serious crime there was in the city and how many of those crimes were being solved by arrest and conviction, how many of those arrested were dismissed by the police magistrates or handled in the juvenile court, how many were dismissed by the grand jury or whose cases were stetted or nol-prossed by the state's attorney and the number of convictions and acquittals, together with the percentage of cases in which probation was granted.

Was not such information already available and easily accessible? The answer is an emphatic "No." Extended and accurate crime statistics are almost non-existent. Only fifteen of the forty-eight states make any pretense of secur-

ing crime figures. Then, too, where figures are obtainable there is no standardized form of tabulation or terminology.

In making any study of the crime situation in a given community it must be remembered that the administration of criminal justice is a single operation working through a number of agencies. The function of the police is to maintain order and to apprehend offenders. The state's attorney then takes up the thread, unless it has been broken at the preliminary hearing or by the grand jury. Then the courts and the prisons finish the task. Any weak link in the chain destroys the effectiveness of the whole. It is of no use to study any one part of the scheme without relation to the whole.

It is the tendency of each of these various agencies to study this process in terms only of its own function. Thus the police department maintains a set of records by which we learn the number of arrests made and the disposition of those arrested. The grand jury records the presentments and indictments. The records of the state's attorney, police magistrates and the criminal courts show the number of acquittals and convictions and the sentences imposed. Then, too, the probation department, parole commissioner and prisons all maintain separate record systems.

It is quite evident that it is of no great value to know simply how many people are arrested unless we know the proportion of arrests in relation to the volume of crime. Nor is it of any particular benefit to know how many people are convicted without knowing the relation which the number of convictions bears to the number of arrests and the extent of crime. It was found necessary, therefore, not only to coordinate all these existing records but also to go back to original sources for other facts and information.

After all these facts are secured, properly assembled and coordinated it is possible to see wherein the machine as a whole is failing properly to function. This in turn inevitably leads to certain specialized studies of some particular phase of the administration of criminal justice, as, for example, probation and parole, police methods, use of the stet or nol pross by the state's attorney, the security of bail bonds and an examination of our criminal laws and procedure.

The next step, once we understand the immediate problem, is to keep alive and sustain public interest, realizing that it is impossible to proceed with a problem faster than public opinion will permit. It is frequently necessary to have an overwhelming mass of facts and through those facts mold, direct and change public opinion by overcoming many age-old beliefs and prejudices. Nor is an aroused public opinion of itself sufficient. Organized action is also necessary. Thus in its final analysis it becomes a question of organized public interest versus organized crime.

It is vitally important for a commission to distinguish between the impartial gathering of facts and a mere hunt or "probe" for official wrong-doing. The work should be done in an impartial, even-tempered way. A commission should be neither "hard boiled" nor sentimental but practical and scientific. Its work should at no time assume the nature of a "probe" or "exposé" but should be a practical painstaking study of the entire situation. Every felony case should be carefully followed through from the time of the original report of the crime until the final disposition of the case.

The mere fact that officials know that each case is being carefully followed has in itself a most stimulating effect. The periodical publication of all the facts showing the record of each of the various agencies engaged in the administration of criminal justice tends to create a competitive spirit and almost invariably results in improvement. It is likewise

possible for a commission to bring about a better public understanding and appreciation of the work and handicaps of a particular agency charged with the administration of criminal justice.

"Even if we hasten the process of criminal justice and make our machinery more efficient will this actually reduce crime?" say the more cynical. "Are we not still ignoring the real causes of crime and approaching the question from the wrong angle?" The answer is that an intelligent and efficient administration of criminal justice *does* actually reduce crime. In explaining just why it does reduce crime let us pause for a moment to consider some of the many theories regarding crime. Originally crime was thought to be the result of innate depravity and the possession of the devil. Later the theory was advanced and is still maintained by many, that criminals are a born type, the result of an atavism or throw-back to savagery, and hence are not responsible for their acts. At or about the same time this theory was advanced another school of thought maintained that crime was due largely to imitation. The battle between the differing groups waxed warm. Some time later a scientific investigation was made of a large group of inmates in penal institutions in England to determine whether or not there was actually a born criminal type which could be recognized by definite physical stigmata. The results showed no real variance between inmates of penal institutions and the students of a great English university. In fact there was found to be as much variance between the inmates of different penal institutions as between the students of two different colleges. Thus another theory was shattered by facts.

Unfortunately, however, those making this study fell into the all too prevalent habit of theorizing, by announcing the belief that all criminals were mentally sub-normal. This belief caught the popular fancy and is widely accepted and believed to-day. Its absolute plausibility accounts no doubt for its so general acceptance.

The lack of scientific knowledge of the norm of intelligence made a real test of the soundness of this theory impossible. It was not until the World War that great numbers of men were given intelligence tests and the norm of intelligence thus more accurately determined. The average of intelligence was found to be much lower than was originally supposed and when our convict population was examined it was found that they received a higher mental rating than did the draft army of the United States, which was fairly typical of our mass population. In this connection it must be borne in mind that the convicts found in institutions represent the lower mental type of criminals, since the more astute frequently escape detection; hence the comparison would seem more than fair to the mass population. It is interesting to note that, generally speaking, the criminals received a higher mental rating than did the guards in the institutions in which the examinations were made.

Therefore, since crime is not due to innate depravity and inasmuch as the Lombrosian theory of a born criminal type has been pretty generally exploded and the sub-normality of criminals proven false, it would seem that actual as well as potential criminals go through the same mental processes as the average citizen. This being true they consider the chances of success or failure of an undertaking just as the average man does. Since the chances of succeeding in a legitimate business are, generally speaking, less than in a criminal undertaking, is it any wonder that those individuals unhampered by character or conscience should choose a career of crime with its greater financial returns and fewer chances of failure?

But by the same method of reasoning, when apprehension becomes more cer-

tain, trial more prompt, conviction of the guilty swift and sure and punishment adequate, professional criminals are brought to realize that the game isn't worth the candle. Crime as a business is like any other business when you take the profit out of it it collapses.

The Baltimore Criminal Justice Commission is one of the local crime commissions which has been a vital factor in doing just those things as far as Baltimore City is concerned. Whereas several years ago only one reported crime in every five or six was followed by arrest now arrests take place in one of every two reported crimes. Cases are tried with a degree of promptness unparalleled in the United States as far as any known records show, as 92 per cent. of the cases tried are tried within three weeks of the date of arrest. Probation, which had been rather indiscriminately granted without preliminary investigation and with little, if any, real "follow up" work, was reduced to proportions within which it could be more properly handled. This action followed the issuance of a report on the subject in which the effects of probation during one year were carefully studied and the results tabulated. The results were undoubtedly disturbing to the complacencies of those who felt content to rest with the formulation of theories. Probation in fact was found to be far different from probation in theory, but it is only through a full and complete gathering and assembly of the facts that a way of betterment is to be found.

It is unquestionably true that existing law is failing to meet new conditions. It has been often said that "legal precepts and processes devised and shaped for pioneer, rural and agricultural society of the nineteenth century are failing to meet the new requirements of present-day America, which is predominantly urban and industrial. The result is growing confusion and uncertainty." England modernized her legal precepts and processes more than fifty years ago after a succession of exhaustive nationwide surveys by commissions of eminent legal scholars. America, however, continues tenaciously to cling to these old forms of procedure long after the country from whom she borrowed them has discarded them.

In this respect crime commissions can be of tremendous help, and in Baltimore, for example, the Baltimore Criminal Justice Commission brought about the abolition of the antiquated fee system in the state's attorney's office and had set up in its stead the modern budget system. The changing of Maryland's constitution was necessary in order to do this, and those of you who have ever attempted to change the constitution of any state know just how difficult a task this was. Here again the gathering, assembling and presenting of facts was the means by which this change in Maryland's organic law was accomplished.

To summarize, therefore, local crime commissions came into being because of a growing public demand for an improved administration of criminal justice. Their purpose is to reduce crime by making the machinery for the administration of criminal justice more efficient. This is accomplished by knowing and interpreting the facts to the public, by organizing and keeping alive public interest to the end that public action is secured.

This movement is in its infancy. That its growth may be healthy and along proper lines is of the utmost importance. It is profoundly encouraging to know, therefore, that the Harvard Law School has worked out a plan broadly national in its scope, for the purpose of assisting more largely and more directly in overcoming the many serious difficulties now hampering the administration of justice and the conduct of business in this country. Briefly its aims are:

(1) To apply in the field of law the modern method of continuous scientific

investigation which has proved of such practical value in medicine, in business administration and in the technical arts.

(2) To enable trained men of outstanding ability to carry on this important work for the general good under the necessary conditions of permanence and impartiality.

(3) To supply the trained assistants who will be needed by the major investigators.

(4) To make the school's great law library more serviceable to investigators and students.

(5) To make the results of investigation available, as promptly as possible, through publication.

(6) To maintain the highest standards of professional training for lawyers.

Such movements as this point the way to future accomplishments.

STAGES OF EVOLUTION AND RELATION TO CRIME

By Professor LANCASTER D. BURLING
VASSAR COLLEGE

The relation between environment and criminal tendencies has had many exponents and they have had an easy task. Somewhat more difficult, however, has been the problem of those who have followed Lombroso in appealing to the predisposing tendencies of hereditary physical traits. We discuss the one and recognize it in our criminal system because we understand it, because science tells us how it works, because it can be remedied. Heredity, on the other hand, we do not understand. Science speaks with certain voice only so far as bodily form and characteristics are concerned. Always there are exceptions, and these increase in number as the objects of our study progress upward in the scale that has genius at the top. Let us see if we can find in evolution a basis additional to those already given by environment and heredity for the science of criminology.

For this purpose intelligence tests seem to offer a valuable starting point. Such tests, founded upon insufficient data and carelessly applied by persons of varying ability to the inmates of our jails and reformatories, led a few years ago to the publication of such statements as that half or more of our criminals were feeble-minded and that for the majority of these it was hereditary. More mature and based on more inclusive data, later intelligence tests of a comparative character gave different and surprising results. For example, the thirty-three hundred inmates of Leavenworth were found to score slightly higher than ninety-four thousand members of the white draft. Statistics now seem to indicate (Curti) that 15 to 30 per cent. of our criminals have a mental age of eleven or less. But, the average mental age of large sections of the draft was only thirteen, and the obviously feeble-minded were not included. So close a correspondence between the percentages of feeble-minded among criminals and in the adult population of the country as a whole would seem to lead to the obvious conclusions that the criminal is little different than his unlabeled brother and that 20 per cent. of the adult population of our country is feeble-minded. These conclusions various people, Curti among them, have been unwilling to accept. I should like for a while to look with you at the propositions implied by these facts and by many

other things in the world around us if we make the necessary correlations and draw the conclusions to which they point and then to try to apply the knowledge so obtained. Let us do this under the headings:

(1) All men are born unequal;
(2) This inherent inequality makes good and evil entirely relative terms;
(3) We now recognize this inequality in our criminal system, but more or less unconsciously;
(4) How can our criminals, unequal by nature, be graded;
(5) How should our criminals, unequal by nature, be treated;
(6) How can intellectual and moral superiority or inferiority be recognized without sacrificing the democratic principle?

(1) *All men are born unequal*—equality being as accidental, shall we say, as twins. In other words, the effects of environment, which loom so large in our criminology, and the hereditary inequalities to which Lombroso appealed are superficial compared to the more fundamental inequalities of soul growth which are the natural result of the evolutionary process. We do not discuss these inequalities of soul age because we have never considered the subject, because we have been taught to believe that there is no such thing, because science says very little about it, because it seems irremediable. Yet we have always recognized that a genius in music or in art was so born. It displays itself too early to be environmental and too capriciously to be hereditary. Travelling far from the beaten track in central Africa I have found among the natives of a little village the one destined by only a slight stretch of the imagination to become the genius of a later day. He had fashioned a musical instrument finer than, and differing entirely from, the tom-toms of the rest and carried it around with him wherever he went. As there are all grades of musical talent among ourselves is it not a logical inference that it would be possible to find persons occupying all the steps between the African and Debussy; that Debussy himself must have progressed along such a ladder? And if in music, and in art and in poetry, why not also in intellectuality, in character?

Let us search for the evidence of inherent human inequalities in our own experiences, in such common everyday facts as I have mentioned and in such facts as these:

(a) The fact of boy and girl prodigies.
(b) The recognition, by our educational system, of superior types and their accommodation, for example, by "opportunity rooms" with separate teachers in the case of the intuitive children of California, and by honors courses and independent and advanced work supplementary to the regular courses in our colleges.
(c) The recognition of inferior types in our public school system and the appointment of psychologists to care for them.
(d) The emphasis placed by educational psychologists upon "individual differences."
(e) The failure of many grown people to profit at all by the teaching given in the schools for adult illiterates.
(f) The recognition of the moron and the semi-moron as identifiable members of our civilization—people who can illustrate an ad, play the traps, do any one of a score of things, and can not write a sensible letter. And if semi-morons, why not quadri- or hexi-morons, etc. Nature can not have segregated the particular types of intellectual capacity which children recapitulate at the ages of eleven or fourteen.
(g) The discovery that large sections of the draft possessed, on the average, the mentality which might be expected of a child of thirteen. Without placing too much credence in the exactness of such figures it is nevertheless possible, with such an average, to appreciate the low figures that will be required to balance the superior figures that must have been present. And, as already stated, the draft did not include the obviously low.
(h) The fact that punishment, even extreme, does not deter.

(i) The different stages represented by the person who commits suddenly a crime for which there appears to be no antecedent in the life of the individual and the person who plans a crime. We shall return to this.
(j) The fact that many criminals feel no remorse for what they have done; the fact that others do.
(k) The fact that writers, attempting the classification of humanity into groups, have frequently been successful in proving for the members of each group reactions which are characteristic. Such, for example, is the classification and relationships proposed by R. Bennett Bean in the paper on "Human types in relation to medicine" announced for this very afternoon before one of the other sections.

Many other indications of these inherent inequalities will occur to you, and each of the lines of thought listed could be pursued at length. But is this necessary? Men seem definitely to be unequal; are we not ready to accept as a working hypothesis the idea that this inequality may be a variable dependent upon the number of times we have tried this experiment of living? We all differ, the one from the other, as do the older and younger children in a family, shall we say, but are personally responsible for the inequalities which characterize ourselves and our surroundings in the life which we are now living. To select one only of the illustrations already listed, does it not seem as if there could be no better proof that men are on various steps of a ladder of evolution and that many criminals are on very low steps, than the fact that punishment does not deter? The mere thought that an act might be seen or found out would be a sufficient deterrent for many; for others the inhibition would be internal. Are there not two classes, those whom punishment would deter (those farther along on evolution's pathway) and those whom it would not (the child souls); and since both of these are included in the classes from which our statistics are derived may not the resulting conflict in the data be the reason for argument with men like Lawes and Osborne?

In the world given to us by science, a world in which law and order prevails, in which every cause has an effect, every effect a preceding cause, a world in which energy is conserved and evolution is the keynote, would it not be surprising if there were present elements so arbitrary, so unrelated, so wasteful, so unevolutionary as that men and women have been cast without predisposing causes of their own manufacture into a particular niche of a world wherein there are all gradations from luxury to want, from refinement to coarseness; into a particular body when the range of choice lay anywhere between the perfect and the crippled or diseased; and have been arbitrarily endowed with minds of a certain type when there could have been chosen for them mental abilities ranging from feeble-mindedness to genius? And, are we to believe that the same nature which has spent several hundred million years in the painstaking evolution of everything from atoms to man's body should dispense with this process in preparing souls, or that she should attempt to crowd within the lifetime of each body the evolution of its soul? May there not be a certain recapitulation in the case of the soul and may not we, fairly able to evaluate the rapid changes which take place in the development of our bodily form, be failing to recognize as recapitulation the various steps in the adaptation of an old soul to a new body, an adaptation which, progressive in its nature, simulates the original evolutionary process to some extent and is mistaken for it?

Now, are we not recognizing in our criminal system the fact of inequalities in mental capacity and character, for that is a part of what I mean by soul age? By all means, even if unconsciously, but since these inequalities enter that system when responsible for an act which comes within the criminal

code let us first discuss the inequalities of human beings in the moral field.

(2) *This inherent inequality makes good and evil entirely relative terms.* In ancient India a high caste man was allowed to go or given only nominal punishment in cases where the penalty to a low caste man was severe (Rajagopalan). Up to the nineteenth century Europe made exceptions in the case of the educated, the clergy, the peerage. In the world of to-day where our criminal laws crystallize a code representing the changing morality of the articulate portions of the citizenship, somewhere therefore about halfway between the top and the bottom, there are people at the bottom for whom the laws should be changed, people at the top who are above all laws. It should not be necessary to state that I do not refer to the class which frequently escapes apprehension or punishment, either because its operations are not defined as stealing, for example, or because it is able to build up a workable defense, but to those who would plead guilty if they had even thought of doing that of which they were accused.

Have you ever been in the Texas "panhandle," "out west" where "cowboys" go down to a domino parlor to spend the evening? Forbidden by law to play pool because of a custom which usually asks the loser to pay for the game, and is therefore gambling, they play dominoes in a hall where all games must be paid for in advance, before winner or loser is determined, and then match fifty-cent pieces to see who pays for the dinner in a restaurant. There I have seen them match coins at a rate which made each chance failure cost the loser as much per second or two as he might have lost in a whole game of pool. Perhaps pool is too slow! My point is that if playing pool (or dominoes) is perfectly proper for those of us who are at a certain stage of evolution, it is more commendable (right) for those who are below us and might be doing worse, it is less commendable (wrong) for those who are above us and know better ways of spending their time. In other words: A on step 99 of the evolutionary ladder and B on step 101 can both move to step 100; but for A it is a step in advance and commendable, good; for B it is a step backward, evil. Then whether an act be evil or not depends upon the person who does it. Of course, but our realization of the fact should speed up our efforts in the direction of individual punishment.

Let me illustrate further, increasing the range between our actors from the nominal one separating pool-playing and non-pool-playing people to one where the gap is very large. For a starving man to take food is—which? For a nation that does not provide enough money to buy the products of its industry and seeks elsewhere for buyers (as if a theater seating three thousand should print only fifteen hundred tickets —Douglas) to send shoddy to natives in one of its colonies is—which? I have seen a man who was in one of the "outposts of empire" sell a piece of starch-filled calico to a native for \$3.00 and enter \$1.50 in the book of a company which declares large yearly dividends. The native received the \$3.00 for palm oil, and for this payment there was the same kind of bookkeeping, so far as agent's profit was concerned. The agent, the company, the stockholders are engaged in a business enterprise which is called "carrying the flag," "developing the backward races," etc. We do not therefore characterize all stealing as stealing; and many other illustrations will occur to you. But we are interested not so much in the crime itself as in the criminal. He must be on some one step of the previous illustration and his responsibility varies with that position. If he steps downward, from however high, he does wrong; if he lives up to the

light he has and steps upward, from however low, he does right.

It is a long time since we hanged a man for stealing a shilling. The witnesses of such an execution could not have thought the "criminal" to be a species by himself. Each must have known why that particular man was being hanged. But are we improving? Do we protest? Do we not separate ourselves from the criminal, and are not those of us who are soiled with the same dirt the hardest on him? It was the people who had sinned who had the stones in their hands. We must realize with Sir Basil Thompson, of Scotland Yard, that "the murderer is rarely a criminal by nature . . . he is just you or I." If you and I are at different levels on an evolutionary ladder so are the criminals. Those who are below us stand where we have stood; those whom we are above will some day stand where we are now. Every person, without exception, is treading his own path; and every path across a swamp is a right path if it arrives at the other side. On this path we all make errors. These may warrant our segregation from other people, but they may not be evil at all; indeed they are not if we are doing only that which is to be expected of one at our stage of evolution. Men credit us with vices, but the "vices of men become steps in the ladder, one by one, as they are surmounted." To each of us, "criminal" or not, will come success; "the only possible failure is to cease trying."

(3) *We now recognize this inequality in our criminal system, but more or less unconsciously*. I have added the word "unconsciously" to the heading because I do not see a basic or conscious recognition of the principle of soul inequality in features which make it possible for you to ask me questions such as the following:

(a) Do we not recognize the mistake of having the same punishment for the same crime committed by different people; is not individual punishment the keynote of modern penology (Ruggles)?
(b) How about the failure of juries to convict under the old (and still prevalent) rigid punishment system, even though the verdict is often complicated by an emotional appeal or by the way in which the case is conducted?
(c) How about the way in which attorneys exercise the right of selecting and rejecting jurors?
(d) Is it not shown in the growth of the principle that all idea of punishment should be eliminated—that we might as well punish a wolf for not being a setter, a range cow for not being a jersey, a jungle fowl for not being a silver wyandotte?
(e) Does not the growing sentiment in favor of the indeterminate sentence afford still another instance?
(f) And the frequent petitions for clemency, how about them?
(g) What about the distinction we draw between first offenders and the "hardened criminal"? To this I answer with a question: Why is it that the favorable conditions at England's farm prison on the Isle of Wight react so quickly on the "incorrigibles" who are sent there?
(h) Have not Boehmer and Kretschmer blazed the way with their classification of criminals into asthenic, athletic and pycnic? And may we recall again the fact of the various classifications of humanity in general which Bean reviews in his paper on "Human Types in Relation to Medicine"?

To all these I answer: Exactly. We do have social efforts aimed at the removal of those causes which tend to retard soul growth or to cripple its expression. We have a penal system which is so conducted that soul age sometimes enters the reckoning. We have many thinkers who realize the presence of the inequalities we are attempting to explain. My belief in the originality of my ideas has always seemed to vary inversely with the extent of my information and I should not be surprised to be told that I am merely calling out "Left," "Left," beside a column that has already been placed in motion. Indeed I offer you nothing new; I am

merely using facts already known to you somewhat as a painter uses paints. As I see it, humanity is being constrained to follow a path which does coincide in large measure with realities. It is always thus. I plead for the acceptance, the valuation of these realities, and the development of a criminal system intentionally based upon them and applied to all who come within its field of action rather than that these things should happen by accident; a system that knows the differences and likenesses between the idiot, the imbecile, the lunatic, the moron and the feeble-minded; a system that appreciates the inequalities of mental and moral stature and recognizes them in the making and administration of its laws and in its social reform activities.

(4) *How can our criminals, unequal by nature, be graded?* The gradual evolution of the intelligence test method is making it increasingly helpful, if wisely used, and such tests may well be the basis of a preliminary sorting out of the men even before they come within the operation of such methods as those of the Mutual Welfare League. The necessity that all prisoners shall be so treated and so graded is the essential thing. I offer, however, for the consideration of those among you who can apply it, the fact that a lunatic, hypnotized, becomes intelligent, able to reason, and the possessor of a keen memory; the fact that a man, unlettered by circumstances, will, in trance condition, read Greek fluently, will play a complicated game to which he is a stranger, or will understand and answer in a language unknown to him in his waking state.

(5) *How should our criminals, unequal by nature, be treated?* Mr. Rajagopalan, in his "Growth of Civilization," points out the fact that where one nation is ruled by another there tends to develop in the ruled a half caste group "with power derived from the rulers but with none of their culture and nobility, a class looked down upon alike by the rulers and the subject race and showing the worst features of both." Realizing that brutality reacts more seriously upon the one who devises it and applies it than upon the one whom we usually regard as the victim, I view with grave concern the growing army of police and detectives, the army of officers in our penal institutions. Run by a staff which is being schooled in brutality, our jails, too many of them, are graduating a stream of students schooled in crime and in nothing else. Our asylums are becoming hospitals; our penal institutions should be universities for the cultural and vocational training of the intellectual, trade schools for the moronic, granting diplomas and union cards. In them should be a field for the keenest of our professors and to them some of the best of our professors will gradually be attracted.

What shall be the first steps in this emancipation? Remove our prison systems from politics, abolish from them all idea of punishment—that of capital punishment in particular, establish self-government, let the men earn their own way and support their families, or earn enough to have families, while they are in prison on an indeterminate sentence, prepare them for graduation into civil life as quickly as possible, and look after them after they are graduated.

Such a program is self-evident; such steps are being taken; they have to be taken very gradually. But I dream of the time when the life lived by the graduate of Sing Sing or Leavenworth, for example, shall make their diplomas valuable, a time when a sentence to such a place will be a real opportunity, a time when criminals incurably dangerous to society will become fewer and fewer, a time when for the others the only disgrace will be failure to so cooperate that graduation will be possible. The officials and the instructional staff of such jails will look for the sources of their own

failure when a man is sent back for a second term. This will not apply to the incurably dangerous, for they will never have been released irrespective of the time which they have spent in the institution.

But let us go deeper. Let us recognize that the acts for which men and women surrender their privilege of going about freely, any acts for that matter, are the final chapters in a cause and effect sequence. The law has for a long time recognized the difference between an act done without thinking and an act planned or premeditated. This is right. Our failure is the requirement, for conviction, that the act shall have been completed. If my information is up to date Scotland recognizes as murder an attempt which would have been murder if death had ensued; France makes a similar recognition in the case of attacks upon public officials; Japan exacts the death penalty for executing or contriving.

It will occur to you that an apparently unpremeditated rash act must have had, during the soul growth of the particular individual, an antecedent mental history which is represented in the present life, or at the moment of commission, only by a predisposition, and that determinism is, therefore, not negatived by our hypothesis. As some one must have said: What we were we do, what we think we are. The act represents the fruit of a previous flower; the thought the flower of a fruit that may ripen. Our criminal code pays too much attention to the former (the finished) and too little to the latter (the changeable, the preventable). To the educational jails already described should be sent not only those who succeed in committing criminal acts, but all those who plan or attempt them. We can thus take a step which may stop the criminal sequence of meditated (mental) cause and final (physical) effect before it does any damage on the physical plane and before it visibly affects others. If to the program we have outlined there is added the impartial application to all, rich and poor, influential and uninfluential, of a criminal code based on the inequality of man and the criminality of attempted as well as accomplished crime our jails, our reformatories, will contain an increasing percentage of individuals with a large I Q, and therefore amenable to an educational process.

Very important also is our share in the guilt of those who fall. We deliberately call attention to pistols as weapons by pasting paper over the extended hand of a man before whom another is falling dead. Impossible, absurd, but true. Our movies depict, before people who live out every detail of the action, express or implied, acts for which our criminal code prescribes penalties; and in cases where the film is not allowed to go this far it shows everything but the actual act. Our novels do the same; our papers spread before a thousand the intimate details of the solution found by some one for the very problems that are confronting them. We are ourselves responsible for the creation of this additional predisposing thought.

(6) *How can intellectual and moral superiority or inferiority be recognized without sacrificing the democratic principle?* We are endeavoring to run our country on the proposition that all men are equal. We have popular referendums, for example, one man one vote, on such questions as (a) permitting an increase in the stock of corporations by a two thirds instead of a majority vote of the stockholders and doing away with the necessity for a sixty-day notice of such a meeting, (b) exempting secondary schools from taxation, (c) taxing short line steam railroads, (d) tax exemption for veterans, (e) restricting the manufacture of oleomargarine. (There were ten other measures and more than twenty constitutional amendments in this particular referendum.) But the

Declaration of Independence merely affirmed certainty that all men were created equal, and a long line of thinkers has stressed the effect of heredity and environment in introducing inequalities. If to these we add the more fundamental inequalities described in this paper democracy bids fair to become the absurdity that it is logically if we look upon it as the final goal. For the purposes of this paper it will be sufficient to realize that if all men were created equal they were probably so created at different times and that they are now equal only in the opportunity that is given to them to grow and to progress upward on the path toward perfection. For this creation took place a long time ago, and the earned advantages and deserved disadvantages of environment and heredity through the ages, as well as in the present, have insured the presence amongst us of souls at all stages of the journey. What solution democracy will find for itself when it realizes the essential inequality of man is difficult to predict. The world has found little fault with monarchy or aristocracy or even oligarchy until they became parasitic. Shall our democracy become so parasitic that it must give way, and if so to what: monarchy, benevolent autocracy, communism, despotism, socialism? Or shall we try a modified democracy based on a classified electorate and run by people who hold office by right of mental and moral stature—a commonwealth in which the strong have duties, the weak rights (Besant)? I do not know.

Just as there is ever an antecedent mental process for every act so is the idealistic program of the 1925 International Prison Conference, for example, an indication of what shall be. So also is our symposium, particularly when it speaks of the future, an augury for that future, and, what is far more important, necessary if that future is to be. The smallness of our room, the fewness of our numbers, matters not at all. A visitor to our planet some score million years ago, as some one has said, would have found the air, the land and the sea well peopled, and dominated by reptiles of almost inconceivable variety and size. Evolution would have appeared complete, the earth to have no room for anything else. Yet the man of vision would have seen, hiding in the trees, a few small insectivorous animals and could have prophesied that they should give rise to mammals and to man. I have great hopes for the future. Is it too much to hope that you who have been trained in the field of criminology and understand it will attempt to prove or disprove or at least to find out whether or not there is anything of value in, the working hypothesis of a student of evolution.

Summary

Endeavoring to find an evolutionary basis for a newer criminology I have become convinced of the reasonableness of the view that all men are born unequal, mentally and morally, and point out (a) some of the features in our civilization which corroborate such a view and the changes which it introduces into our ideas of good and evil; (b) the fact that criminals usually appear to represent a fair cross section of society, and that we all differ in soul growth, that we are all on different steps of a ladder of evolution which reaches from the bottom to the top with opportunity for all to travel upward to the end; (c) that varying grades of intellectual capacity and moral appreciation have not been fortuitously bestowed, and that such a deterministic view based upon an evolutionary process stretching through the ages is the only one consistent with a world of law and order in which nothing is but in which everything is becoming. I acknowledge that, due to my lack of knowledge, I may be retelling an old story, and that I am merely using facts

with which you are all familiar, the only element of novelty in the paper being the conclusions which it reaches. I acknowledge the presence in our criminal system of the recognition of a fundamental inequality in mankind, but point out its probably unconscious character and plead for its real acceptance as a working hypothesis, introducible into our criminal code, our penal system, our social reform activities. I suggest (a) the possibility of using the psychological methods of hypnosis in determining the soul age of those members of society who are illiterate by circumstance instead of by nature; (b) the gradual conversion of our jails into universities and trade schools to which some of the best of our professors will come, and the building up of a tradition that shall make wilful failure to graduate and get a diploma a real disgrace; (c) the recognition in our criminal code of the necessary connection between previous thought and subsequent action and the necessity for terminating this sequence before it has an effect in the physical world by sending to our jail-universities those who plan or attempt crime; (d) our own responsibility for a large part of this predisposing thought. Finally I discuss briefly the bearing upon our democratic experiment of the fact of intellectual and moral superiority and inferiority.

IMMIGRATION LAW ENFORCEMENT

By Professor DONALD YOUNG
WHARTON SCHOOL, UNIVERSITY OF PENNSYLVANIA

EFFICIENT enforcement of the present immigration laws of the United States is impossible. This is true in spite of the fact that public opinion is convinced of the need for rigid immigration restriction and deportation legislation. Ordinarily it is an easy matter to secure a reasonably strict enforcement of legislation which is so fully in accord with popular sentiment as our immigration laws seem to be. Where dissenting voices are so loud and so frequent as they are in opposition to the Volstead Act common disregard for the law is to be expected. The immigrant problem, however, appears to be different in that the law is popularly approved yet not enforced.

This non-enforcement is in large measure due to exceptional circumstances found in the United States rather than to neglect or inefficiency on the part of the Immigration Service. While it is not within the province of this paper to comment on that service it seems proper to say that the immigration officials have done their work remarkably well when their financial, geographical, legal and other handicaps are considered. These handicaps will become apparent as our discussion proceeds.

The most obvious problems of enforcement of any set of immigration laws in the United States should be mentioned but require no discussion. They are as follows:

(1) The thousands of miles of United States boundaries, varying in character from swampy seacoast to arid desert wastes.

(2) The opportunities for the maintenance of a high standard of living in the United States which naturally attract multitudes from foreign congested areas.

(3) The millions of aliens already in the United States who by their presence make it difficult to apprehend the illegal foreign resident.

(4) The immense areas of our cities and country districts which afford security to hunted aliens.

(5) The necessity for the United States to do the pioneer work in the field of immigration legislation. No other country has had our problems, though many of the newer lands, such as Australia, Argentine, Brazil, Canada and South Africa, are beginning to meet them on a smaller scale. They have the advantage, however, of being able to look to our experiments for advice on what and what not to do.

Such handicaps as these are no one's fault and can not be avoided. An examination of the legislation itself, however, may show defects or omissions in some measure avoidable. We shall begin our examination by an analysis of the admissibility requirements established by Congress for prospective immigrants.

Prospective immigrants are considered undesirable because of their (a) race or nationality, (b) individual defects of mind or body, (c) personal ideals and conduct, and (d) because of unfavorable economic or social conditions in the United States. Resident aliens may also be deported for reasons of the first three types mentioned. It may be that a share of the enforcement difficulties encountered by our immigration officials lies in the nature of the undesirability tests legally provided.

From the most ancient recorded times it has been good form to judge the merits of an individual by the color of his skin, the shape of his nose, the clothes he wears or even the language he speaks. Foreign characteristics, cultural or biological, apparently significant or obviously unimportant, have been sufficient to classify a man as necessarily inferior. "Barbarian" and "gentile" were rarely intended as terms of praise. This state of mind is as common to-day as ever. Certainly our immigration legislation evidences its wide acceptance by the "barred zone" exclusion of Orientals and the thinly veiled discriminations of the act of 1924 in favor of aliens from Northern and Western Europe.

This attitude of racial discrimination was one of the first important causes of modern immigration law violations, and it is becoming increasingly important as our national pride develops and is written into our alien legislation. Beginning with our timid Chinese exclusion act of 1882, growing more bold with its continuation in 1892 and 1902, and with the extension of the principle of racial exclusion in 1908, 1917, 1921 and 1924, we now say quite frankly that we do not want any Oriental immigrant laborers and only a few others.[2] We have with growing assurance asserted a belief in our own superiority. As each additional "race" has been put on the undesired list thousands of its members have attempted to smuggle themselves across our borders, and with no little success.

Part of the difficulty here lies in the inability of the "inferior" excluded races to appreciate our point of view. Why should Italians be restricted while Mexicans are allowed in, almost without limit? Why should the Slav with his centuries of glorious history be less desired than the Irish? Why should an American woman lose her citizenship through marriage to a Hindu Oxford graduate but not through a marriage to the lowest African savage? Consequently, the so-called "inferior races" feel no compunction about entering our country illegally, for they are sure that our law is founded upon an error, and while its violation may be a crime, it is to them no moral wrong. So long as

[2] The following major restrictive immigration provisions show the increasing tendency of the United States to act in accordance with a belief in the racial superiority of its early settlers:

- 1882—Chinese exclusion legislation
- 1892— " " continued
- 1902— " " "
- 1907—Gentlemen's Agreement limiting Japanese Immigration
- 1917—"Barred Zone" provision of act of 1917
- 1921—Quota limitation of act of 1921
- 1924—More strict limitation of South European immigration and extension of "barred zone" provision to include Japanese

they have an incentive to leave their native lands for ours they will continue to run our borders. No adequate way has been devised to stop them, though millions of dollars have been spent in the attempt.[3]

Do not misunderstand me. I am not arguing that all races and nationalities should be admitted in equal numbers. There may be biological reasons for their exclusion, but none have been scientifically established in spite of the constant efforts of such students as Stoddard, Madison Grant and Laughlin.[4]

Undoubtedly there are social reasons why the restricted and excluded races should be kept out of the country. Try as we will, however, unless we are willing to spend untold millions on the development of our embryonic border patrol we shall continue unable to apprehend more than a mere tithe of those who attempt entry by evading the inspection which would instantly list them as members of undesired races.

Individual defects of mind or body, like racial characteristics, are relatively easily observable by inspectors at ports of entry. During the fiscal year which ended June 30, 1926, about 300,000 immigrant aliens and 191,000 non-immigrant aliens were admitted to the United States. During the same period some 20,000 aliens were refused admission. The surprising fact is that only a relatively small number of these refusals were based on the more serious physical and psychological defects of the applicants.

Four hundred and fifty-two applicants were refused admission because they were "physical or mental defectives," while 507 refusals were the result of "loathsome or dangerous contagious diseases." In view of the frequent charges that immigrants are a menace to our native stock, such a report of the immigration commissioner general requires explanation.

The small number of refusals directly charged to disease and other individual defects is partly attributable to the fact that many inferior immigrants denied admission are hidden in such listings as "likely to become public charges," under which heading 3,590 aliens were returned to foreign shores.[5] Many thousands more of would-be immigrants were prevented from setting sail for the United States by the improved legislation and administration which now provides for foreign inspection in some countries by Public Health Service and steamship examiners, and directs our consuls to deny their visa to obviously ineligible applicants in all countries.[6] Others, knowing our standards for admission, do not attempt to pass inspection. For these reasons it is difficult accurately to estimate the number of defective and diseased aliens kept from entering our territory.

While such healthy effects of our immigration legislation are to be desired, there is nevertheless one important unsought result, and that is the increased pressure of smugglers on our borders.[7] We have through wise restrictions on

[3] For illustrations of the increased pressure of potential immigrants created by the quota act of 1924, see House of Rep., Com. on Immigration and Naturalization, No. 69.1.6.

[4] For evidence in support of this point of view, see: McDougal, "The Indestructible Union," (Especially Ch. 6) Boston. 1925.

Grant, "The Passing of the Great Race," New York, 1916–1919.

Stoddard, "The Rising Tide of Color."

Laughlin, Statements before H. of Rep., Com. on Imm. and Nat., Serials 5A and 1B.

[5] Department of Labor, Bureau of Immigration, mimeographed report for fiscal year 1926, released in August, 1926.

[6] For statistical statement showing more efficient law enforcement resulting from use of "British Plan" of foreign inspection of immigrants, and of consular visa system, see Annual Rept. of Com. Gen. of Im., 1925, p. 2, and H. of R., Com. on Im. & Nat., No. 69.1.6, 1926, pp. 30/31.

[7] An official summary of the alien smuggling situation can be found in the 1925 Annual Report of the Commissioner General of Immigration, pp. 12–21.

diseased and defective aliens added a large group of potential border runners to those already mentioned in our discussion of the debarred races. This is not an argument for the abolition of physical qualifications for admission, but merely the statement of an evil which necessarily follows their application and makes our immigration laws harder to enforce.

Personal ideals and conduct may also furnish us with desirable standards for the exclusion and deportation of unwanted aliens. A matter of taste, however, becomes involved when we do not want an alien because he believes in anarchism or polygamy or has been divorced for adultery or has been convicted of a crime involving "moral turpitude." One might well consider the impossibility of obtaining an accurate definition which would enable an immigration inspector to determine which immigrants were "anarchists, or aliens entertaining or affiliated with an organization advocating anarchistic beliefs," and therefore subject to exclusion. "Moral turpitude" is a vague term over which officials may well squabble. Adultery, a belief in polygamy, prostitution and other immoral intent are certainly hard to detect, as are several other types of technicalities barring individuals. It may safely be said that any admittance test which amounts to nothing more than a question of personal opinion or the admission of, or conviction for, an "immoral" act, can not be enforced except in isolated instances. This is well demonstrated in the annual reports of the commissioner general of immigration since such provisions have been in effect.[8]

[8] Well-selected source material from which a good idea of the difficulties of immigration law enforcement, now and in the past, may be obtained, can be found in: Abbott, "Immigration, Select Documents and Case Records," Chicago. 1924, and in "Historical Aspects of the Immigration Problem," Chicago, 1926, by the same author. These include contemporary articles and statistics, court decisions and excellent case records.

During the fiscal year ending June 30, 1925, the following number of aliens were debarred from entering the United States for reasons of personal opinion or conduct:[9]

Anarchists, or aliens entertaining or affiliated with an organization entertaining anarchistic beliefs	2
Prostitutes, and aliens coming for any immoral purpose	55
Aliens who are supported by, or who receive the proceeds of prostitution	1
Aliens who procure or attempt to bring in prostitutes or females for any immoral purpose	42
Criminals	251
Vagrants	11
Professional beggars	2
Paupers	2

In short, while 458,435 aliens were admitted during the year, only 98 who applied were found to belong to what the government terms the "immoral classes"! Only 251 had committed crimes involving "moral turpitude"! Only two were anarchists! The countless pages of Congressional committee hearings and debate, all the public agitation against such dangerous people, have done no more than save us from the attacks of this handful of the unwanted!

Obviously, the law is not being enforced, unless you are willing to assume that Europeans are not subject to the world's vices, as are the citizens of our own country. Of course, the figures quoted do not state the case quite fairly. Many individuals have been deterred from applying for admission by the mere knowledge of our restrictive laws, as was the case in regard to mental and physical requirements. Our foreign consuls have stopped others. Possibly a few other causes of exclusion should be added to our list to make it complete, as, for example, "chronic alcoholism," which kept eight aliens from our arid shores. Reason tells us, however, and so does the

[9] Annual Rept. of Com. Gen. of Imm., 1925, pp. 152–155.

Immigration Service, that not all of the half million who entered could have obtained admittance honestly.

Social and economic conditions in the United States which may be unfavorable for the admission of immigrants are given slight consideration in our legislation. Immigrants are, on the whole, admitted in bunches, so many of such nationality in a certain period of time. A closer correlation between conditions in the United States and the number and types of immigrants might well make our laws more enforceable, but so little experimental work in this field has been done that we can do no more than express a hope.

Let us now assume for the sake of argument that the legally established tests for admissible immigrants are the best which can at present be devised, and that prospective immigrants are being subjected to them with discrimination. Granting such to be the case, loopholes for illegal entry would still be plentiful in the many exceptions which permit aliens to land in excess of quotas and in some cases after superficial examination.

Alien seamen, for illustration, have been allowed to land for sixty days for the purpose of reshipping for foreign shores. When these seamen decide that their occupational preference lies in the coal fields of Pennsylvania, the mills of Birmingham or the wheat fields of the middle west, it becomes a difficult and an expensive task to obtain their deportation. It is estimated that 38,000 alien seamen deserted their ships at United States ports during the fiscal year of 1924 and about 20,000 during 1925. Many of these have of course left the country. How many we do not know, nor is there any way of finding out. This one loophole in our legislation, however, is considered of such importance by Congress that during 1924 and 1925 over five hundred pages of testimony were taken by House and Senate committees dealing with this problem alone, and no practical means for stopping the leak were disclosed.[10]

For a second illustration of the loopholes in the immigration legislation, one may turn to the quota act of 1924, which, be it good or bad, has as its main purpose the limitation of the number and a qualitative selection of industrial and agricultural workers who may become more or less permanent residents of our country. This purpose is in part defeated by important special exemptions from the normal quota provisions.

It has been indicated that almost a half million aliens were admitted during the fiscal year 1926. Of this number, less than half, or 157,432, were charged to the various quotas. The remainder included 88,758 "non-immigrant aliens" and 249,916 non-quota immigrants. These non-immigrants include such groups as the following:[4]

Temporary visitors for	
Business	19,951
Pleasure	36,663
In continuous transit through the U. S.	25,574
Ministers of religious denominations, their wives and children	1,335
Students	1,920

Such groups present tremendous problems to our enforcement officers, problems which have not been solved and will not be solved except through an increase in governmental employees and expenditures. University officers will tell you how they must constantly be on their guard in admitting foreign students in order to avoid serving as aids in violating immigration restrictions.[11] Europeans have heard the call to religious service just as they made up their minds to emigrate to America. A pleasure trip

[10] H. of Rep., Com. on Imm. and Nat., Serial 2B and No. 69.1.5; and Senate Com. on Imm., Hearings on March 18, 1926.

[11] There are hundreds of schools and colleges of all sorts on the approved list issued by the Secretray of Labor (see H. of Rep., Com. on Imm. and Nat., Serial 1B, pp. 97–104) and each has its own entrance requirements and general standards. The resulting confusion is obvious.

has many definitions. It is not impossible for an alien to change his status from one of the above groups to a group in the limited class. The job then is to catch and deport him.

The deportation of undesired aliens after they have entered our land is even more difficult than their rejection at the port of arrival. Commissioner General Hull stated in his report for 1925 that "the experience of the fiscal year just closed has demonstrated the accuracy of the statement made a year ago that the deportation of aliens found to be unlawfully in the United States is rapidly becoming one of the most important functions of the Immigration Service." Of the 7,233,595 unnaturalized aliens found in the United States by the census of 1920, possibly 20 per cent. are here illegally.[12] Nine thousand, four hundred and ninety-five aliens were sent out of the country during the year mentioned by Mr. Hull. Ten thousand, nine hundred and four were deported during the fiscal year 1926.[4] That there are thousands more illegally remaining is admitted by the Immigration Service and by the legislators who drafted the acts now in force, and this fact is accepted by them as a matter of course.[13]

Many of these illegal residents (I do not know what proportion) are such because of their illegal entry. They have sneaked across the border, entered as seamen or passed inspection falsely. Most of them can not now be located except by some such radical measure as a complete alien registration. Our Secretary of Labor has recommended such a provision, and Mr. Hull has accepted it as the only way out of a difficult situation.[14] However, if these aliens have escaped our boundary guards, how much more tedious and expensive will it be to detect them in our cities and on our farms.

Other aliens have rendered themselves obnoxious while legal residents in our country. Certain criminals, political radicals, paupers, prostitutes and immoral individuals are legally though not always actually deportable.[15] Whatever the merits of such reasons for deportation, adequate enforcement measures have not been provided.

For example, only 412 of the immoral classes and 793 criminals were deported in the fiscal year 1926, though many times those numbers from the millions of aliens in our country have made themselves liable to expulsion for such reasons.[16] I quote from Dr. H. H. Laughlin:

> Of course the present law contemplates keeping out of the United States all aliens who are likely to become public charges, but there are so many loopholes in the administration of the law that when one makes a first hand investigation of the custodial institutions of the country he finds many aliens in them in violation of the purpose of our immigration laws, particularly of the act of 1917.
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> For example, during our survey of 1922 we found in 445 of the larger custodial state institutions in the United States approximately 44,587 foreign-born white persons who entered the United States in violation of the spirit of the law. The reasons they have not been deported are, first, some have been in the United States longer than five years and consequently they are not deportable under present law; second, many of these state custodial institutions, of which there are approximately 700 in the United States, do not feel that it is incumbent upon them to take the initiative in deporting deportable persons.[17]

Dr. Laughlin might have added other reasons of practical administration which make it probable that only a few

[12] Annual Rept. of Com. Gen. of Imm., 1925, pp. 9, 12.

[13] See statements of Mr. Curran, former Commissioner of Immigration at Ellis Island, in H. of Rep., Com. on Imm. and Nat., Serial 1B, p. 12 ff.

[14] Annual Rept. of Com. Gen. of Imm., 1925, pp. 13, 26.

[15] Jenks and Lauck, "The Immigration Problem," 6th ed., pp. 532–533.

[16] Annual Rept. of Com. Gen. of Imm., 1925, pp. 159–163.

[17] H. of Rep., Com. on Imm. and Nat., Serial 1B, p. 55.

of our present deportables ever will be deported. A simple list of such reasons would be as follows:

(1) Unwillingness of local agencies to cooperate in the enforcement of a national law.
(2) The vague legal definition of several causes for deportation, such as the provision for the expulsion of certain political radicals.
(3) The administrative difficulties of the task of locating, convicting and expelling offenders.
(4) The expense of the process.
(5) The necessity for obtaining passports, which may be refused or reluctantly given in deportation cases by such countries as Russia, Turkey, Poland, Germany and England. Arrested individuals may also withhold information essential to the securing of a passport.[18]
(6) The inevitable opposition of public opinion if the law were carried out to the letter.

It is consequently not unfair to say that our deportation legislation is so designed that it can not be justly enforced in regard to even a fair percentage of our illegal residents. On the contrary, it is subject to grave misuse, as are all such blanket laws, for purposes of persecution and political advancement, as was so commonly charged during the régime of a former attorney general. However, in view of the general post-war 100 per cent. Americanism agitation, supported and kept alive by numerous active and powerful patriotic propagandist organizations, there is little likelihood of any real change in the near future.

It is thus evident that whatever benefits have resulted from our immigration and deportation laws (and there have been important benefits therefrom) there are nevertheless unjustifiable violations in spirit and letter which are all too frequent, though unavoidable by the nature of the situation, which permit thousands of aliens illegally to enter and illegally to remain in the United States.[19]

Were we to include the violations of our naturalization laws, which might well be considered an integral part of our immigration legislation, the outlook would be even more dismal. Space forbids such an inclusion. We must turn to a consideration of the means for amelioration of present conditions. Three major suggestions can be offered. They are the usual suggestions offered for the repair of any system of laws which does not function smoothly.

First, we may rely on more and more stringent laws, and an enforcing staff increased in numbers and efficiency. This is the plan which now seems to be in favor with our law-makers, our Immigration Service and the public. It is usually the first and most obvious proposal. A casual reading of Senate and House committee hearings demonstrates the frantic search for laws without loopholes. The Immigration Service is asking for additional men and money. A border patrol has recently been established, and is doing good work, but since its very beginning it has been insisting that it can not do efficient work without additional funds. More immigration inspectors are constantly being requested for our ports and for deportation proceedings. Deportable aliens have admittedly been allowed to remain because money was not available to pay their passage out of the country. There is no end to these requests in sight. If there were, we might feel inclined to grant the wishes of the proponents of this plan. Meanwhile, it might be well to think of the effects of a policy which is resulting in separate national police systems to

[18] H. of Rep., Com. on Imm. and Nat., Serial 1B, p. 18.

[19] Safford, in "Immigration Problems," New York, 1925, shows some of the troubles of Ellis Island officials in a popularly written account of his experiences there.

enforce each separate set of national laws.

Second, there is the possibility of adapting our immigration laws to actualities rather than to pseudo-scientific race theories. This could be done by excluding, admitting and deporting aliens in accordance with their individual qualities, scientifically determined, and with proper regard for the industrial and social capacities of our country. Such scientific tests would supersede our present regulations, which are in part, a rather large part, based on the application of undemonstrated racial and social myths. It is interesting to note that no recognized leading anthropologist, biologist, psychologist or social scientist was called to testify before our Congressional immigration committees in the hearings before our recent legislation on the subject was adopted. Most of the testimony taken was given by people who, regardless of their scientific or practical qualifications, were unquestionably biased. There is little reason to wonder why our laws are not functioning.[20]

Third, a policy of "hands off" has many advocates who believe in it not only for sentimental reasons but also because they are convinced that natural laws of population alone can solve such problems. As an immediate program this seems inadvisable, if only for social reasons. There is no likelihood of its adoption, for its adherents are relatively few. We should dismiss it from consideration and confine our efforts for immediate improvement to the first two suggestions.

However, it may be well to remember the possibility that the ultimate solution to our immigration problems may be based on the idea of natural population laws, as the advocates of a "hands off" policy so stoutly maintain.

After all, people do not migrate between countries having equal ratios of resources to population, and in view of the rapid expansion of the United States since the Civil War, it may not be so many years, historically considered, before the motive which is causing these hundreds of thousands of aliens to press upon our shores has disappeared. For the present, we must guard against the relatively temporary troubles which necessarily accompany periods of population adjustment.

Science, not race prejudice, not 100 per cent. Americanism, not economic selfishness, not religious bigotry, not even pseudo-science, must furnish that temporary guard. A few flexible protective measures which are in accord with modern knowledge of race and race relations can now be recommended in general terms. They have, I believe, the merits of the scientific method and of an elasticity which permits adjustment to changing conditions. They will not stop all immigration law violations, for smuggling, at least, will continue regardless of the scientific or unscientific nature of our legislation, as long as residents of other countries have any incentive to come to ours. Improvement should nevertheless result from the adoption of the following recommendations.

First, eliminate the impossible mental and moral desirability tests from the present legislation. As a substitute for the present scatter-shot method, it is suggested that broad powers to exclude or deport objectionable aliens will be given to responsible officials who will act on individual cases rather than blindly follow blanket laws.

[20] For the quality of the "evidence" presented by "experts" to Congressional immigration committees, see such documents as H. of Rep., Com. on Imm. and Nat., Serial 1B, 2A, Nos. 69.1.9 and 69.1.11 as typical of its numerous hearings.

Second, immigrants should be selected on their individual merits rather than on a racial or national basis.

Third, the quantity and quality of immigrants admitted should be limited by the economic needs of the United States, determined from year to year by a fact-finding commission.

Fourth, the admissibility of an immigrant should be determined in his home country through the cooperation of the foreign government concerned, our Consular Service, our Public Health Service and possibly the transportation company involved. (This recommendation is now being put into operation.)

Fifth, adequate supervision of resident aliens should be maintained through the cooperation of the federal government with existing public and private agencies, such as hospitals, jails, courts, police, schools, philanthropic associations, and the like. In view of the multitude of existing social facilities which could be utilized in alien supervision with but little annoyance to the agencies or to the foreign element, it seems worse than useless to establish a cumbersome national immigrant registration system.

Sixth, a governmental program for the social assimilation of the immigrant is badly needed. It could be developed as a part of our fifth recommendation.

These recommendations find little opposition among students of race and population problems and could be of great value in a program for immigration law enforcement. Their enactment, however, will be impossible until the scientific facts on which they are based are known to more than a handful of specialized students.

GRAVITY ON THE EARTH AND ON THE MOON[1]

By FRED. E. WRIGHT

GEOPHYSICAL LABORATORY, WASHINGTON, D. C.

THE story of Sir Isaac Newton's discovery of the law of gravitation illustrates well the importance of little things. In 1666 a plague was devastating Europe and because of it Newton was forced to return home from the university at Cambridge. He was then twenty-four years old. One day in August while he was sitting in his garden under an apple tree an apple fell to the ground; a commonplace event, but in Newton's mind it raised the questions: "What is the mysterious force that causes the apple and all other bodies to fall toward the center of the earth? Under what law does it operate? Does it pervade all space? If so, it probably varies with the masses involved and inversely with the square of the distance between them." Newton inferred further that the planets are held to their courses around the sun by this same force; likewise the moon in its orbit around the earth.

To test the law he compared the distance through which heavy bodies fall in a second of time at the earth's surface with the distance the moon falls in the same time toward the center of the earth. He found that the moon in its orbit falls toward the earth 1.4 mm in a second, whereas on the basis of his new law he computed that it should fall 1.02 mm in a second; a large discrepancy. He therefore concluded that some other factor must enter the problem to modify the result and turned his attention for the time being to other problems, not realizing that in his computations he had assumed an incorrect radius of the earth. Sixteen years later he learned of the measurement of a degree of latitude by M. Picard, of France; with the new value he recomputed the acceleration of the moon toward the earth, on the basis of the law of gravitation, and found it to agree with that deduced from the moon's orbit. A year later, in 1683, he communicated his results to the Royal Society and included a dozen propositions on the motion of the planets that had been previously deduced empirically by Kepler from actual observations.

Since Newton's time the subject of gravity and gravitational attraction has been under constant discussion; but there are still many features about which we need information, especially when we consider problems involving gravity as one of the factors.

There are in geology many problems that require for their solution consideration of conditions that are at present beyond the range of our experience. We live on the surface of the earth and we are prone to interpret things in terms of what we see here. To us the mountains are enormous and the oceans are exceedingly deep at certain points. But if we view the earth from a distance we realize that, in comparison with the diameter of the earth, the heights of the mountains and the depths of the oceans are exceedingly small; so small in fact that, if on a globe three feet in diameter the Himalaya Mountains were represented to scale, they would appear to have the thickness of only two postal cards, and the thickness of the part of the earth's crust accessible to us would be represented by a layer of five postal cards.

[1] Lecture given at the Carnegie Institution of Washington on November 27, 1926.

Nevertheless by experiment and by field observation we are learning much about the form of the earth, its interior and its composition. The study of geology is now passing through one of the most interesting phases of its development, and this is due in large measure to the fact that more exact data are becoming available by which the correctness and adequacy of any suggested hypothesis can be tested.

Of the many factors that enter geological problems gravity is one of the most important. It is not only of theoretical interest but also of immediate practical value to certain industries, especially the oil and mining interests.

How is gravity measured? All methods for measuring gravity in the field furnish only relative and not absolute values; they may conveniently be grouped into several classes according to the particular physical property that is chosen for measurement. The quantity to be evaluated is the earth's pull at a given point. The degree of accuracy required is one or two parts in a million.

The method suggested first by Newton for this purpose and the only one that has thus far proved entirely satisfactory is the method based on the free swinging pendulum. In its modern form, it consists of a support on which several pendulums may be swung if desired. Probably the best model is that made and used by the U. S. Coast and Geodetic Survey. Not only must proper supports and proper shaped pendulums be employed; but many factors, such as temperature, pressure, arc of the swinging pendulum and the swinging motion of the supports, must be taken into account and proper corrections made for them. The result is that much time is needed to make an accurate measurement of gravity.

Recently Dr. Vening Meinesz, of Holland, has been successful in applying the pendulum method to the measurement of gravity at sea. For this purpose he uses three pendulums mounted to swing in the same plane. By means of mirrors attached to each pendulum and by allowing light to be reflected from them to a movable photographic sheet he obtains a record of curves that enables him to eliminate the horizontal accelerations of the points of suspension due to the movement of the ship, providing this movement is not too large. Thus far he has made satisfactory measurements only on board a submerged submarine. He has recently travelled across the Atlantic, through the Panama Canal and across the Pacific to the Dutch East Indies and made measurements along the course. These measurements are of the greatest value because of the information they give us regarding the shape of the earth.

The free swinging pendulum method depends primarily on the measurement of time. For this purpose accurate chronometers are used, also radio time signals. At present an effort is being made at the Bureau of Standards to use a tuning fork to serve as an accurate time source in place of chronometers or time signals. If these experiments are successful the time required for a gravity measurement will be greatly shortened.

Another group of methods is based on the elastic deformation either of a gas or of a solid. Of the gas deformation type two instruments have been devised, one by W. G. Duffield and another by L. J. Briggs. In the Duffield type gas is enclosed in a glass chamber and is held at constant volume by maintaining mercury at a definite contact level. Settings are made by altering the level of the mercury in an adjacent column until contact at the given level is just established. In the Briggs apparatus a glass cylinder is filled with nitrogen which is maintained at constant volume by a column of mercury whose height

depends on the weight of the mercury itself, and this in turn on the gravity pull. The temperature is held constant by immersing the entire apparatus in an ice bath. The height of the mercury column is adjusted by bending a small zigzag capillary tubing above the gas cylinder. The chief defects of these types of apparatus are gradual changes in the glass apparatus itself, its sensitiveness to external conditions, such as temperature and barometric pressure, and to the pumping effect when observations are made at sea.

Of the solid elastic deformation types of instruments, three may be mentioned, namely, the quartz thread balance of Threlfall and Pollock, a new type that is being developed at the Geophysical Laboratory, and the Eötvös balance. The Threlfall and Pollock apparatus was developed in the nineties of the last century in Australia. It consists essentially of a very fine silica glass thread or fiber held horizontally between two supports, one of which is rotatable about an axis. Attached to the silica glass fiber at its center is a light cross arm. By rotating one support the thread is twisted and the cross arm is gradually raised to the horizontal position; approximately three complete turns about the axis are required to do this. The angle of twist is read off by a sextant. The position of the end of the arm is observed through a microscope. With this apparatus Threlfall and Pollock carried out some field determinations and concluded that under favorable conditions the values were accurate to better than one part in 100,000, or to 10 millidynes.

In any static apparatus which is to measure to one part in a million a number of factors enter that can not be avoided. Among them are: (1) Lack of perfect elasticity in the materials used; (2) the relatively large effect of temperature on their rigidity; (3) the difficulty of suppressing vibrations in the elastic system. In the Geophysical Laboratory instrument, which is similar in principle to the Threlfall and Pollock balance, tungsten wire is used in place of silica glass fibers; the damping of the elastic vibrations is accomplished by the use of the tapering spirals combined with the cross arm near its position of horizontality. In this apparatus there is no fixed zero point, the reading being the number of turns required to carry the arm from one position of horizontality to the second. This is of the order of five to eight complete turns. Readings to ten seconds of arc are made or, under these conditions, to about one part in a million. Temperature corrections are eliminated to a large extent by embedding the apparatus in ice. The humidity is maintained constant; also the pressure. One part in a million means control of the temperature to .02° C.

The behavior of the elastic system itself is most remarkable. Hooke's law of proportionality between applied load and resulting deformation actually does not apply to one part in a million but is valid to less than one part in 10,000. When a load is applied the rate of deformation is rapid at first but falls off with the time according to a definite law; under load the deformation continues for days and even years but with ever-decreasing rate, so that after a year it is hardly perceptible. Sir Richard Threlfall has informed me that his silica glass thread after bearing a load for thirty years shows no measurable change even after many days' observation.

This so-called elastic afterworking is, I believe, a surface effect. A surface is one of discontinuity and even though inside a single crystal perfect elasticity may obtain for small loads, at its surface the strains are probably not regularly distributed and give rise to the elastic afterworking. If given time the elastic deformations produced by light

loads no doubt return to the original configuration, at least to one part in a million. Experience with the tungsten spirals has proved that in case of distortion in one direction (say right-handed twist), if the cross arm is raised to the opposite direction the untwisting begins at the point reached by the arm in the first position and so on. In fact the development of the torsion gravity instrument is contributing much to our knowledge of elastic afterworking and of the law it obeys. It is astonishing to find how accurate is the elastic memory of a piece of tungsten wire. It means that in order to obtain concordant results with a method based on the elastic deformation of a solid the observer must follow very closely a definite procedure and adhere to it strictly if an accuracy of one part in a million is to be attained. To work out the most favorable procedure requires much testing and more time than one might think. Suffice it to state that in our tests at the Geophysical Laboratory Mr. England and I are making progress.

Another instrument is the Eötvös torsion balance for the measurement of the horizontal components of gravity. It is in effect a modification of the Cavendish balance. A light aluminum cross beam is suspended horizontally by a long fine platinum-iridium wire. At one end of the beam a metal mass is attached; at the other end an equal mass is suspended by a fine wire. When the instrument is set up, the horizontal pull by a mass of heavy material below the surface is greatest on the nearer lower mass suspended from the end of the beam. The beam is deflected horizontally a measurable amount. Eötvös showed that he was able to measure with this balance extremely small attractions amounting only to 10^{-9} dynes. With it the horizontal components of gravity are ascertainable, also the gravity gradients or changes in gravity with distance in the N-S and E-W directions; also the difference between the principal radii of curvature of the geoid surface and the directions of the principal sections of that surface; in short, the shape of the geoid surface itself, provided a sufficient number of stations are occupied and the absolute value of gravity is known at one point. The Eötvös balance has rendered very valuable service to the oil companies in this country and abroad in the location of salt domes and other subcrustal inhomogeneities.

We have now described briefly several methods for measuring gravity. Let us, before proceeding to the discussion of the significance of gravity data, take an excursion to the surface of the moon and seek to interpret some of its surface forms in the light of the conditions that prevail there, namely gravity about one sixth of that on the earth and no atmosphere or running water. This is a more difficult task than one might imagine, because we geologists have been accustomed from childhood up to look upon the land forms we see as the result of the action of a number of forces, among which water in its several forms and the atmosphere play a decisive part.

In order to bring our minds to bear upon the moon and its surface features, let us consider first the experience that an artilleryman would have on the moon. Were he to fire a 75-mm gun on the earth his ranges would be between 9,000 and 15,000 yards (5.1 and 8.5 miles) depending on the type of his field piece. On the moon his ranges would be very much greater, namely 230 to 280 miles or more. Were he to fire a Big Bertha, such as the Germans used against Paris during the war, with a muzzle velocity of a mile a second, the range, instead of 75 miles, would be 2,250 miles or over one fourth the distance around the moon. In other words for the same charges the ranges on the moon are twenty-five to forty fold those on the earth.

What is the significance of this extreme dispersion? Consider a volcano in action on the moon. Its materials are hurled into space with velocities like those on the earth; but instead of falling back into the crater as on terrestrial craters they are flung far and wide. The crater floor is left cleaned out down to the molten lava if lava be there. This factor of great dispersion must be adequately considered in any discussion of the moon's surface features. There gravity is so reduced that rocks weigh only one sixth as much as they do on the earth. Everything so far as structural strength is concerned is on a Brobdingnagian scale.

With these relations in mind let us consider the two theories of the formation of lunar craters that have aroused the most discussion, namely, the volcanic and the meteor impact theories. Objection to the volcano theory has been made because lunar craters do not resemble terrestrial craters in detail. I submit that under the conditions that obtain on the moon, one can not expect much similarity between lunar and terrestrial craters. We have not yet established adequate criteria by which we can test the theory of the volcanic origin of the craters. On the other hand, it has been asserted as a strong argument against the meteor impact hypothesis that the craters are almost uniformly circular in outline, whereas one should expect elliptical shapes to be developed by meteors striking the surface at low angles. In the first place, it is not certain that this is mechanically necessary; in the second, when we realize that meteors strike the moon at full speed without retardation by an atmosphere as on the earth, a situation arises that needs investigation. Under these conditions the meteor projectile traveling, say, 10 to 20 km per second on impact penetrates some distance into the moon's crust, sets up an aureole of intense compression which rebounds elastically and ejects some material. Moreover, by the abrupt stopping of the meteor its kinetic energy of translation is available both for mechanical deformation and for conversion into heat sufficient to melt the meteor itself and the adjacent rocks, to set free occluded gases and even to volatilize some of the material, thus producing an explosion analogous to a volcano in its action. In case the meteor were to penetrate deeply to a molten layer of rock a real volcano would result. In either case the original shape of the crater would be much changed by the action of forces set up by the impact. The circular shape of the craters on the moon may not be therefore construed as an argument against the meteor impact hypothesis. More data are required before a definite decision can be arrived at regarding the mode of origin of these craters, to say nothing of other perplexing features on the moon.

Returning now to the earth we find that its surface, like that of the moon, is also irregular with mountains and ocean deeps. The question arises, "How are these mountain masses sustained? Why do they not spread out and become flat like the plains?" Geologists have observed that the land, which we consider to be so stable, has in the past risen and sunk repeatedly, also moved laterally, so that at many places rocks originally in horizontal beds are now folded, tilted and crumpled as though there the earth's crust had been shortened by very appreciable amounts. What have been the causes of these movements, both vertical and horizontal?

Geologists realize that in problems of this kind we are considering conditions beyond the range of our experience and we seek primarily to gather all possible facts that bear on the problem so that in the light they shed we can test this and that hypothesis. We must expect the advancement of all sorts of hypotheses

to account for the observed relations and realize that in the present development of the science no single hypothesis is entirely acceptable. One of the most important facts bearing on these problems is that expressed by the term *isostasy*.

Three quarters of a century ago it was found in Northern India by triangulation that the difference in latitude between two places *Kalianpur* and *Kaliana* was 5°23′42.294″, whereas the astronomical observations, referred to the plumb line as zenith, showed a difference of 5°23′37.058″, a discrepancy of 5.236″ between the two methods. Kaliana is only sixty miles south of the Himalayas, and it was thought that the attraction of the mountains had affected the plumb line. But Archdeacon Pratt proved on calculation that if the average density of the Himalayas were 2.75, the discrepancy should have been 15.885″, or three times that actually found. Sir George Airy suggested in 1855 that the mountains must therefore be supported from beneath and are, as it were, floating on a denser substratum as a log or an iceberg floats in water. The iceberg, with a density less than that of water, extends downward into the water to a distance such that the mass of the displaced water is exactly that of the berg. Hence the attraction due to the berg on a plumb line set up some distance away would offset by the attraction, in the opposite direction, of an equal mass of ocean water and there would be no appreciable deflection. To quote Airy:

> I conceive that there can be no other support than that arising from the downward projection of a portion of the Earth's light crust into the dense lava; the horizontal extent of that projection corresponding widely with the horizontal extent of the tableland, and the depth of its projection downwards being such that the increased power of flotation thus gained is roughly equal to the increase of weight above the prominence of the tableland. —It is supposed that the crust is floating in a state of equilibrium. But in our entire ignorance of the *modus operandi* of the forces which have raised submarine strata to the tops of high mountains, we can not insist on this as absolutely true. We know that it will be so to the limits of breakage of the tablelands; but within those limits there may be some range of the conditions either way. It is quite possible that the immersion of the lower projection in the lava may be too great, as that the elevation may be too great; and in the former of these cases the attraction on the distant stations would be negative. Again reverting to the condition of *breakage* of the tablelands, it will be seen that it does not apply in regard to such computations as that of the attraction of Schehallien and the like. It applies only to the computations of high tracts of very great horizontal extent, such as those to the north of India.

Archdeacon Pratt objected to Airy's flotation hypothesis on the grounds that it postulates a comparatively thin crust; that the crust is lighter than the liquid substratum on which it floats; and that, just as a protuberance outside the thin crust is accompanied by a protuberance inside down into the liquid, so a hollow, such as occurs in deep seas, postulates a corresponding hollow beneath it; this leads to a law of varying thickness which no process of cooling could have produced. Pratt suggested in 1859 and 1864 that:

> Below the sea level under mountains and under plains there is a deficiency of matter, approximately equal in amount to the mass above sea level; and below ocean-beds there is an excess of matter approximately equal to the deficiency in the ocean when compared with rock; so that the amount of matter in any vertical column drawn from the surface to a level surface below the crust is now and ever has been, approximately the same in every part of the earth.—In order to attack this problem mathematically it is necessary to assume some law of distribution of the mass, that the calculation may be possible. I assume that the deficiency or excess of matter is distributed uniformly to a depth bearing a fixed ratio to the height of the land or the depth of the ocean. The actual distribution most likely differs from this. But this is taken as an average. We must expect, for these reasons, to find that the hypothesis is not satisfied with exact precision.

Archdeacon Pratt's main hypothesis accounts, then, for the development of surface features as due to the vertical expansion of columns of rock down to a certain depth; the expansion is the same at all points of the same column, but differs from column to column. In other words, below mountain areas there is a deficiency of mass down to a certain level, while under the oceans there is an excess of mass down to the same level at which level the pressure is practically uniform in all directions. In his later paper of 1871 Pratt mentions other causes that affect crustal conditions:

> As the crust contracted and brought into play the prodigious force of compression, which would inevitably cause the crust to give way at the weakest part and produce anticlinal lines, crushing, sliding and interpenetration, there would be a slight increase of mass in some parts on this account.

Both Airy and Pratt recognized that the compensating cause must be looked for in a deficiency of matter below elevated land areas and an excess of matter below ocean deeps. Pratt especially refers repeatedly in his papers to the higher densities of sub-oceanic rocks. The two writers do not agree, however, on the mechanism, by which this state of equilibrium or balance is attained and maintained. The two hypotheses are still under discussion and final decision regarding their relative merits has not yet been reached. Notwithstanding this uncertainty regarding its mode of operation, the facts of geodesy and geology do show that this theory of isostasy, as it was first called by Dutton in 1889, is valid and that the earth's crust rests approximately in equilibrium upon a heavier substratum that yields slowly to stresses and acts over the span of geologic periods as though it were a liquid. On this theory large elevated areas are raised because, like the icebergs, they are of lighter material than the adjacent lower lying masses and float in equilibrium on the subjacent heavier layer. Conclusions of this character were drawn by Pratt from a series of pendulum observations made in India in 1865.

Dutton defined isostasy as follows:

> If the Earth were composed of homogeneous matter its normal figure of equilibrium would be a true spheroid of revolution; but if heterogeneous, if some parts were denser or lighter than others, its normal figure would no longer be spheroidal. Where the lighter matter was accumulated, there would be a tendency to bulge, and where the denser matter existed there would be a tendency to flatten or depress the surface. For this condition of equilibrium of figure, to which gravitation tends to reduce a planetary body, irrespective of whether it is homogeneous or not I propose the name *isostasy*.

In discussing the subject further Dutton notes that in areas in which deposition is taking place subsidence is the rule, while in regions where erosion is active, elevation predominates. To quote further:

> It seems little doubtful that these subsidences of accumulation deposits and these progressive upward movements of eroded mountain platforms are, in the main, results of gravitation restoring the isostasy which has been disturbed by denudation on the one hand and by sedimentation on the other. The magnitudes of the masses which thus show the isostatic tendency are in some cases no greater than a single mountain platform less than 100 miles in length, from 20 to 40 miles wide and from 2,500 to 3,500 feet mean altitude above the surrounding lowlands.

In his paper Dutton does not specify a definite thickness for the crust. Reasoning as a field geologist he infers that, coupled with the lateral transfer of material on the surface of the earth, there must be subcrustal transfer of material in the opposite sense. He affirms:

> Whenever a rise of land occurs one of two things has taken place; the region affected has either gained an accession of mass or a mere increase in volume without increase of mass. We know of no cause which could either add to the mass or diminish the density, yet one of the two must surely have happened. But the difference of the two alternatives in respect to

consequences is immense. If the increase of volume or an elevated area be due to an accession of matter, the plateau must be hoisted against its own rigidity and also against the statical weight of its entire mass lying above the isostatic level. But if the increase of volume be due to a decrease of density there is no resistance to be overcome in order to raise the surface. Hence I infer that the cause which elevates the land involves an expansion of the underlying magmas and the cause which depresses it is a shrinkage of the magmas. The nature of the process is, at present, a complete mystery.

Previous to the publication of Dutton's paper, geodesists in Europe especially had taken great interest in this problem because of its bearing on the larger problem of the exact figure of the earth and had developed several different methods for comparing the observed values of the deflection of the plumb line and also for gravity with those deduced from the theoretical spheroid of rotation. The first method was due to Bouguer in 1749; in his reduction of gravity values account is taken of the height of the observation station above sea level and also of the rock mass between it and sea level. His formula is based on the assumption that the crust is strong enough, without deformation below sea level, to support loads above sea level; the assumption is also made, but for computation purposes only, that the rock mass between any station and sea level is in the form of a horizontal plate extending indefinitely and of average surface density. This formula resulted in anomalies roughly proportional to the height of the station, and becoming quite large in elevated regions. This result naturally led to the *free air reduction method,* in which the mass of the mountain is disregarded altogether, and correction is made only for height above sea level. While this method largely eliminated the anomalies in elevated level regions, it gave results in mountaineus regions sometimes even more discordant than those with the Bouguer formula, the anomalies having a distinct relation to the height of the station above or below the surrounding region. While the free air reduction is a crude application of the idea of isostasy, it has been shown that it overcompensates for a station above the average level of the region, and undercompensates for a station below the average level.

The theory of isostasy, as expressed by Dutton from a geologist's viewpoint, aroused much discussion. In the United States the first serious effort to test the theory was made by Dr. George R. Putnam in 1894 and 1895, while he was a member of the U. S. Coast and Geodetic Survey. He determined the relative force of gravity at thirty-eight different stations, widely distributed over this country, and reduced these and twenty-nine earlier observations on coasts and islands, by a method which he called the Faye or *average elevation* reduction method, but which was actually a new method devised by him and a great improvement over the *Bouguer* and *free air reduction methods.* Instead of subtracting the attraction due to the entire mass between the station and sea level or of disregarding it altogether, Putnam considered only the attraction of a plate of thickness equal to the height of the station above or below the average elevation of the surrounding topography within a radius of one hundred miles. In addition Putnam applied a correction for departure of the topography about a station from that of a horizontal plain, following the customary practice of subdividing the region into zones and compartments, where this topographic correction was appreciable. The values obtained by Putnam by this simple method accord remarkably well with those obtained much later by Hayford by a more complex but theoretically better method. Putnam inferred from his measurements and computations that:

> The results of this series would therefore seem to lead to the conclusion that general continental elevations are compensated by a deficiency of density in the matter below sea level, possibly in much the same way that the portion of an iceberg standing above sea level is compensated by the difference in density of ice and water below the surface, but that local topographical irregularities, whether elevations or depressions, are not compensated for, such irregularities being maintained by the partial rigidity of the Earth's crust.

His conclusion is that there is a fairly close condition of isostatic equilibrium; that the departures from perfect isostasy indicate that single mountains may be supported as extra loads on the earth's crust; but that these local loads are to be considered as regionally compensated.

Quite independently of Putnam, G. K. Gilbert, in discussing the significance of Putnam's results, adopted a reduction, similar to that employed by Putnam and called by him a *reduction to mean plain,* but he used the average elevation within thirty miles of the station instead of the one hundred-mile limit adopted by Putnam. Gilbert obtained anomalies similar to those derived by Putnam, but materially larger. He concluded from his results that "the whole Rocky Mountain plateau regarded as a prominence on a broader plateau, is sustained by the rigidity of the lithosphere." This conclusion was modified by Gilbert in 1912 in the light of later data to accord with the position taken by Putnam.

The next investigator in this country to consider isostasy was J. F. Hayford. His contributions are of the greatest importance and included investigations not only into the deflection of the plumb line and its bearing on isostasy and the figure of the earth, but also into the isostatic compensation of topography and its influence on the intensity of gravity. Dr. W. Bowie collaborated with Dr. Hayford in the gravity work and has carried it on independently since their joint paper of 1912. The work of these two men, together with that of the geodesists of India and of Helmert in Germany, has established the theory of isostasy as a fact fundamental in the development of the surface features of the earth.

Hayford realized that gravity is universal in its action and in his treatment of the problem included the entire surface of the earth. He adopted the Pratt hypothesis of density deficiencies and excesses in columns down to a certain level; continents exist because the crust underlying them is composed of relatively light material; the floor of the ocean is depressed because the crust below is composed of dense material. He prepared a practical and workable scheme for computing for any given station the gravity effects produced by the masses distributed over the entire earth's surface down to an isostatic depth that he was able to ascertain by computation. In this work a definite surface of reference is used and the value of computed gravity or deflection of the vertical for a given station is compared with the observed value. The difference between the observed and the computed values is called the gravity anomaly.

In his extended report in 1909 in which deflections of the vertical were used Hayford considered several different distributions of isostatic compensation, namely, uniform compensation extending to a depth to be determined; compensation concentrated chiefly at the surface and decreasing downwards; compensation restricted to a layer of given thickness, say ten miles, and buried at a depth to be ascertained. The sets of computed deflections, obtained on the basis of these different assumptions, agreed so closely that their differences were much smaller than the accidental errors. He also considered the floating crust or Airy hypothesis and found that if twenty-five miles be the thickness of the crust below areas which are at sea

level, then beneath mountainous areas, such as Nevada, Utah, California, the thickness of the crust should be thirty-eight miles and all the isostatic compensation should occur between the depths twenty-five and thirty-eight miles below sea level. Therefore, the mean isostatic depth under mountainous areas should be greater than under areas only slightly above sea level. Hayford concluded that, because his data indicated a greater depth of compensation for the latter areas than for mountainous areas, the floating crust or Airy hypothesis is not valid for the United States. More recent data, especially by Bowie, prove, however, that the depth of compensation under mountainous areas is probably greater than under areas only slightly above sea level. Hayford's objection to this hypothesis is therefore no longer valid.

The hypothesis finally adopted by Hayford, namely, that the earth's crust is in a state of perfect isostasy with each topographic feature, however small, compensated by a deficiency or excess of mass directly underneath it, appeared to him to be the most plausible and at the same time was the simplest to treat mathematically. In his earlier investigations he found the most probable isostatic depth to be 113.7 km; in subsequent work he derived from the deflection data the value 122.2 km. Later work by Bowie has shown that in this country the more probable value is about 95 km (59 miles) as derived from gravity data in mountainous regions; when all the stations of the United States are used, many of them over plains and coastal regions, a lower value, 60 kilometers (37 miles), was derived, but this value is less certain than that obtained from the mountain stations.

Computations by other geodesists and by other methods have led to about the same or smaller isostatic depths.

The features of uncertainty in the theory of isostasy are no longer the fact of isostasy itself, but rather certain details and in particular the mechanism of the process. Colonel Burrard, of the Indian Geodetic Survey, has aptly said:

> Geodesy has produced much evidence in favor of the view that the condition of isostasy exists throughout the Earth's crust, but it has produced no evidence of the process by which isostatic readjustments are constantly being made. Geodesy teaches that in a region where an extra load of rock is accumulated, the underlying crust decreases in density and whenever rock is removed or eroded the crust underneath increases in density. I, therefore, conclude that the condition of isostasy is brought about by the force of gravitation acting upon a crust, the structure of which is not understood.

Before discussing these details let us consider briefly what we know of the crust of the earth down to a depth of say sixty miles.

(1) In the first place the distribution of gravity anomalies proves that whatever is the cause of these anomalies, whether extra loads supported by a competent crust, or inhomogeneities in densities of buried rock masses near the observing stations, they are local in character and near the earth's surface, within one hundred kilometers probably.

(2) The study of earthquake waves and their propagation has proved that at a depth of 60 km the velocity of propagation is that characteristic of an ultrabasic peridotite, such as dunite, and not that of a gabbro or granite.

(3) The depths of the centers of earthquake disturbances rarely exceed 40 km, according to Mohorovicic.

(4) The thickness of the radioactive granite layer, on the assumption that radioactivity either falls off exponentially or is distributed uniformly through a layer of finite depth, has been shown by Jeffreys to be about 16 km.

(5) The great outpourings of basalt over vast areas of the continents indicate that not far below the surface at these points there is a layer of basaltic com-

position heated to a temperature approaching the melting region.

(6) The compositions of the first ten miles of the earth's crust have been ascertained by Dr. H. S. Washington by computing the densities from chemical analyses of collections of rocks from different parts of the world. The results of his labors prove definitely that continental rocks are lighter than ocean basin rocks; in particular that the average density of the igneous rocks of a region varies in the opposite sense as the average altitude. By taking into consideration elevations and assuming that the average rock densities for each elevation are maintained relatively down to a given depth of equal pressure for all surface elevations, he finds the depth of this *isopiestic* level, as he calls it, to average about 59 km.

(7) From the data of the average elevations of continents Joly has computed, on the assumption that granite of density 2.67 rests on basalt of density 3.00, a thickness of 31 km for the granite layer.

All evidence that we have gathered indicates that at a depth of 30 to 60 km a rather rapid change in rock composition and in density occurs and that as we go down from the surface the rocks become more and more basic and heavier and that the temperature rises.

To summarize we may state that whatever be the mechanism which causes isostasy to function, it is confined essentially or chiefly to a layer 100 km more or less in thickness; the departures from isostasy are essentially local in character, probably covering areas one hundred miles square more or less.

We come now to the consideration of the mechanism by which isostasy is or can be attained. From the time of Hayford geodesists have adopted, partly because of ease of computation, the Pratt view, namely, that surface irregularities are compensated by a deficiency or excess in density in the column directly below the surface feature. This leads to the determination of a definite isostatic level at which all columns of the same horizontal cross section extending to the surface have equal masses.

At the present time it is a serious question whether the Airy flotation hypothesis of compensation at lesser depths, usually about one half of the depths obtained by the Pratt method, does not represent the situation more correctly than the Pratt compensation hypothesis.

One of the reasons why geologists have found it difficult to accept the theory of isostasy in the form stated by Pratt is the assumption of a mysterious expansion or contraction of the mass directly below a given surface feature, such as a mountain mass, in order so exactly to compensate for the shift of load. There is something unnatural about this assumption, as geodesists themselves have admitted. The question arises: Are the differences between the theoretical and observed values of gravity eliminated as well by the Airy theory? A recent paper by Heiskanen, of the Geodetic Survey of Finland, seeks to answer this question. For the purpose he compares the results obtained by the Pratt and by the Airy methods under different assumptions for seventy-one stations in the Caucasus; for forty-seven stations in Europe; twenty-seven stations in the Alps; sixteen stations in Italy; eleven stations in Spitzbergen, and fifty-six stations in the United States. For the United States he finds that the Airy hypothesis on the basis of a crustal thickness of 50 km accounts somewhat better for the gravity values than does the Pratt hypothesis. For the Alps the crustal depth is 41 km; for the Caucasus 77 km; for Southern Norway 32 km. In general his results show that in many regions there is not so much to choose between the two hypotheses and

that neither the depths of compensation of the Pratt hypothesis nor the crust thicknesses on the Airy view are the same the world over, but are different in different areas.

Still more recently, Jeffreys has considered the two hypotheses and, by treating the general problem by the methods of spherical harmonics applied to the gravitational potential, has ascertained that for wave lengths or distances between a maximum positive value and a maximum negative value exceeding 100 km there is little to choose between the two hypotheses; that the distinction might be made for shorter wave lengths, but these do not appear to exist; that therefore a given Pratt isostatic depth is equivalent to an Airy compensation of about half that thickness; "that the uniform compensation of the Pratt hypothesis to a constant depth is observationally equivalent to compensation concentrated at half that depth which is approximately what is implied on Airy's view; that the decision as to whether the compensation conforms to the Pratt type or to Airy's or whether its horizontal distribution is local or regional, can not be made by geodetic means, but requires an appeal to physical and geological considerations." In other words, geodetic measurements alone are not competent to decide between the two hypotheses.

The fact that the Pratt hypothesis considers primarily expansion or contraction of volume accompanied by little horizontal crustal movement accounts well for mountain uplift, but it does not explain folding and thrusting such as is observed on a large scale in so many parts of the world. The maintenance of isostasy during mountain formation and the lateral shift of materials at the surface are not adequately explained by this hypothesis. Recently Dr. Bowie has suggested that during uplift and mountain formation chemical and physical changes take place in the underlying rock masses that cause expansion; but in a physical-chemical system subjected to load or external pressures the law of Le Chatelier states that we should expect under those conditions physical-chemical changes within the system itself to take place in the opposite direction, namely, changes that tend to contraction and to an escape from the load. It is difficult to imagine changes in mass, such that, for example, after the formation of a delta the density of the loaded prism should decrease, unless it be through expansion on heating or through an increase in volume occasioned by melting or by the release and expansion of volatile components.

If we concede small finite strength to the underlying crustal material Airy's hypothesis or mechanism apparently stands the test better. It involves only generally accepted mechanical principles and is consistent with a compensation uniformly distributed through a finite depth, but a depth varying as the surface elevation varies. Hayford showed that the same distribution of gravity values can be obtained by assuming either uniform distribution of the abnormality in gravity in depth or concentrated at a given depth near the surface.

Jeffreys has considered whether the compensation is locally or regionally distributed, and finds that in a region of deposition or increasing load the deformation should occur at first just outside and along the margins of the loaded area; the compensation will therefore be regional. The same holds true for areas of denudation. This corresponds with the view reached years ago by Putnam, Barrell, and still earlier by Airy. Jeffreys' general conclusion, based on geological and physical grounds, is that the Airy flotation hypothesis meets the situation somewhat better and permits not only vertical but also horizontal movements and hence folding and

thrusting on a large scale, without serious disturbance to isostasy.

A weakness of the Airy hypothesis is the assumption that a crust, weak enough to be in isostatic equilibrium, is still competent to transmit thrusts great enough to form mountains with the accompanying compensating projections below and to maintain these projections in the hotter and weaker subcrustal region; also that an area of deposition, such as a synclinorium, which implies an increase in density in the underlying crust to provide for the progressive settling of the basin, should be maintained for a long period; and then later, as a result possibly of expansion due to heating, melting and release of volatile components, should become a mountain region in which the effects of tangential compression and thrust, as well as those of vertical uplift, are clearly shown. This objection to the Airy hypothesis is, however, not confined to it alone, but applies to all the hypotheses that have been proposed to explain the mechanical problem postulated by isostasy.

Data gathered by geodesists on the horizontal components of gravity (deflection of the vertical) and on the acceleration due to gravity (pendulum data) prove that the actual figure of the earth (geoid) approaches very closely to that of the theoretical spheroid of equilibrium; the departures from this surface of equilibrium are expressed by the gravity anomalies and these are found to be small. This condition of approximate equilibrium is, in effect, the meaning of the term isostasy, as proposed by Dutton; namely, a tendency toward a figure of equilibrium in the shape of the earth despite the many factors, such as erosion, deposition, earth movements, volcanic action, that tend to disturb the equilibrium. Isostasy is a fact, and the close approach of the figure of the earth to a spheroid is the expression of this fact. The crust responds to the disturbing factors by adjustments within itself that tend to offset these factors and to restore the isostatic balance and figure of equilibrium; from this we infer that the crust is mechanically weak with respect to superimposed loads. The fact that gravity anomalies, even though small, persist the world over and throughout areas in which the rock masses are relatively homogeneous, proves, however, that the crust has some residual strength of a local nature.

Geologists have observed in many parts of the world the effects, in rock masses, of thrusting and folding on an immense scale; this indicates the action of large horizontal or tangential forces; and this in turn requires for its operation a crust of no small mechanical strength.

We are thus confronted by an awkward situation. It is difficult to reconcile the idea of a crust that, at one and the same time, is weak with respect to vertical forces (loads), but is sufficiently strong to transmit horizontal thrusts of great magnitude and to store up energy as energy of compression. We know from earthquake phenomena that stresses of appreciable magnitude do accumulate in the earth's crust and that, when the stresses in the heterogeneous rock masses become equal to the breaking strength of one of these masses, rupture may take place and an earthquake result; if the weak member is spread over a wide area and subjected to somewhat different conditions of stress, the rocks may yield by flowage and relatively slow movement. It is these two opposing characteristics of the earth's crust, isostasy and the ability to transmit horizontal thrusts, that geologists and geodesists encounter and have not yet been able to incorporate into a mutually satisfactory geological theory. The chief reason for this difficulty is our very inadequate knowledge of the behavior of materials under the conditions that obtain in great het-

erogeneous masses at depths within the crust and over long stretches of geological time.

It serves no useful purpose for geologists to deny or to ignore the fact of isostasy; nor for geodesists to brush aside the fact of horizontal thrusts on a large scale. With respect to the two main hypotheses, the Pratt and the Airy, to account for the isostatic adjustment or control, it is probable that both hypotheses are correct in part and that the factors postulated by both hypotheses are of importance. In addition, other factors may enter the problem of which we have little knowledge. The problem is so large and has to do with such heterogeneous materials and diverse conditions of pressure and temperature that we can not expect a single hypothesis to cover adequately all the possibilities that may arise. What is needed is more detailed information regarding the mechanical properties of the materials of the crust. This information will be gathered only slowly and by careful observations in the field and in the laboratory.

It seems to me that a critical test between the Pratt and the Airy hypotheses might be obtained from seismograph records. On the Airy hypothesis the dense peridotitic layer under high mountain areas should be depressed more than it is in ocean basins or seaboard regions; on the Pratt hypothesis the depth to this layer should be more uniform the world over. With the gathering of more gravity data and possible accumulation of short wave data a further test should be possible.

Jeffreys has shown in his book on the earth that the greatly increased age of the earth, as deduced from radioactive surface heating, means that the contraction theory is more than able to account for all the crustal shortening involved in mountain formation, past and present. This factor, coupled with the Airy theory of isostasy, gives to him a satisfactory explanation of the several types of mountain formation.

Still a different explanation is that offered by Joly in his recent book on "The Surface History of the Earth." Accepting the Airy version of isostasy as a fact he seeks to provide the mechanism for keeping isostasy in action by the disturbing effects produced by the radium content of the rocks. He defines isostatic equilibrium as connoting a true flotation of the continents in a substratum of basaltic character, this substratum being for the greater part overlain directly by the oceans. He assumes further that the quantities of the radioactive elements, uranium and thorium, found in the continental igneous rocks are valid for all continental rocks and that the uranium and thorium content in the plateau basalts indicates the radioactive state of the substratum. He considers the continental crust to be about 31 km thick.

As heat from the radioactive transformations increases and is stored up in the lower part of the crust which is near the melting temperature, its temperature is raised and actual melting takes place with consequent radial expansion of appreciable magnitude. The radioactivity is greater under the granitic continental areas than under the oceans. As melting proceeds the ocean crust becomes so thin that tidal action becomes important and currents are set up in the molten subcrustal basalt such that the hotter magma from beneath the continental areas exudes as it were along the eastern margins of the continents, especially Asia, in their general drift from east to west. This east-to-west movement with excess heating and extrusion and intrusion of vast quantities of magma, together with crumpling of the crust along weak, thin crust areas, is considered by Joly competent to account for the surface features of the earth and at the same time to do no violence to isostasy.

After a period of intense volcanic and mountain activity the suboceanic superheated areas cool down slowly, say for 5,000,000 years, after which a new period of heating extending from thirty to sixty million years begins. It is not feasible here to examine further into the details of Joly's hypothesis.

Besides the hypotheses already outlined there are many others, but enough has been said to indicate how varied and unlike are the suggestions now made by geologists, geophysicists and others to account for the surface features of the earth. Through it all we have recognized the fact that, whatever be the correct explanation, the earth's crust is in a state approaching isostatic equilibrium and that the departures from this state are due to factors local in character.

Among the most important weapons we have in the attack on the general problem are gravity measurements and seismic records. It is important, therefore, that a rapid field method be devised for ascertaining relative gravity values; that intensive work be done on the development of seismographs which shall produce records relatively free from distortion and also that we learn better how to interpret the seismograph records themselves. Further work on the radioactivity of rocks is desirable.

In this brief review we have considered gravity, its measurement and that tendency toward gravity equilibrium in the figure of the earth that is expressed by the term isostasy. We find in nature everywhere a tendency or a striving toward equilibrium, which, however, is never attained because of the action of other forces. So it is with the phase rule when applied to the rocks; so it is with evolution; we find the approach toward equilibrium, but almost never the attainment of the goal. Always there are disturbing forces and ceaseless changes and shifts, never-ending activity in all phases of nature from the atoms themselves to the island universes. These departures from equilibrium are of special interest to the scientist; in isostasy they still await an entirely satisfactory explanation.

PHONOPHOTOGRAPHY IN THE MEASUREMENT OF THE EXPRESSION OF EMOTION IN MUSIC AND SPEECH

By Dean CARL E. SEASHORE

UNIVERSITY OF IOWA

I

THE field for psychological investigation herein outlined is defined by the statement that everything that the musician or speaker conveys to the listener is conveyed on the sound wave; we can intercept this sound wave with the camera and photograph it in as fine detail and on as enlarged scale as we desire, so that every characteristic of sound transmitted may be accounted for in terms of measurements on these sound waves.

To restate the point—ideas or meaning as conveyed in words; sentiment, emotion and impulse as voiced; instrumental music of all kinds—all that makes music or speech, as such, meaningful, beautiful or ugly is conveyed on the sound wave. The analysis and measurement of the sound wave furnishes full and adequate data for a scientific account of the facts. Thus modern phonophotography opens to us an enormous new field for investigation and for the laying of foundations for the science, the esthetics and the pedagogy of music and speech.

It offers us in particular a new approach to the psychophysics of the expression of emotion. In the psychophysics which was the making of modern psychology we controlled the stimulus; in this psychophysics we measure the output. Even the expression of emotion through music or speech may now be measured with fully as high degree of precision and with the same ease that we used to control the stimulus in the psychophysics of sensation.

The purpose of the present paper is not to discuss apparatus and methods of phonophotography, but rather to picture in high relief the scope and significance of the utilization of this method, drawing examples from our experiments up to date. The whole technique centers upon the recording of the sound wave on the principle of moving pictures and the reading and interpretation of such records for the solution of problems in the theoretical and the practical aspects of psychology and esthetics of music and speech.

When one considers the apparently infinite manifold of musical and spoken sounds, their meanings and their affective values, it is a great satisfaction to realize that all these may be reduced fundamentally to four measurable factors of the sound wave, *viz., frequency,* or its reciprocal, wave length, which gives pitch, *amplitude* which gives intensity, *duration* which gives all the time values, and *form* which gives the tonal quality or timbre. Rhythm, consonance, harmony and volume are, of course, expressed in terms of combinations of these fundamental measures.

Let us illustrate in turn what may come from each of these four basic measures—wave length, amplitude, duration and form. Figure 1 is a sample of a section of a film recording a baritone voice. The smooth sine curve is a record of a tuning fork of 100 vibrations per second, which serves as a time line. The irregular curve is the record of the voice. The pitch of the tone at any moment is

FIG. 1. SECTION OF RECORD OF A BARITONE VOICE.

determined from such a record either by measuring each successive wave in the tone sung on the hundredth of a second scale or by determining what portion of a wave or how many waves occur in one, two or three hundredths of a second, whichever may prove a convenient unit of measurement.

In this manner every aspect of *pitch* performance may be recorded. Suppose that we wish to record the exact pitch (melody) in the singing of an Indian. A record like Figure 1 is made at the rate of about four feet per second and the length of each wave is measured and plotted. If we then draw a solid line through this plot, we shall have a pitch graph of the note as actually sung, showing the pitch in detail for each moment of the duration of the notes. This may then be transferred on a modified musical staff, as in Figure 2. Here we simplify the musical staff so as to adapt it for scientific purposes and substitute the detailed graph for the conventional note. If this song were published in musical notation, the first note would probably be recorded as a whole tone on F with the comment that the Indian does not hold the tone firmly. Our graph shows that he attacked the note below D♯, fluttered around with great freedom for a second and a half and reached as high as F♯. Only an actual graph of this kind can show or describe what he did sing. In this manner we can represent the pitch aspects of any song or instrumental performance or even speech.

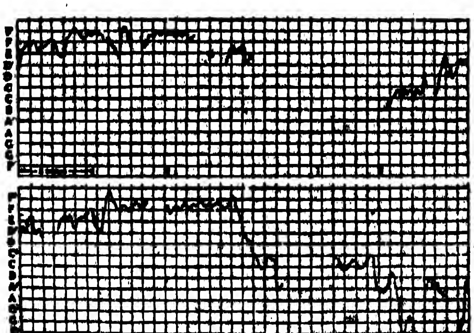


FIG. 2. THE FIRST PART OF AN INDIAN SONG AS TRANSCRIBED BY THIS METHOD. (FROM A PHONOGRAPH CYLINDER LOANED BY MISS FRANCES DENSMORE, OF THE SMITHSONIAN INSTITUTION.) [FROM METFESSEL.]

To convey some idea of how comprehensive such pitch readings are for the reconstruction and the interpretation of musical features, we may set forth some of the principal musical factors which we can study by this method, as follows:

TABLE I

PITCH FACTORS IN A MUSICAL PHOTOGRAM (IN TERMS OF WAVE LENGTH OR FREQUENCY)

I. Mean pitch: absolute, relative, perfect intonation and sustaining.

II. Deviation from mean pitch:
- (1) Erratic intonation and sustaining.
- (2) Periodic deviation: vibrato, tremolo, flutter, trill, etc.
- (3) Progressive deviation: sharp, flat.
- (4) Mode of transition: glide, crescendo, tie, slur, etc.
- (5) Attack and release: direction, rate, extent, and form of approach or release.
- (6) Grace notes and other embellishments.

III. Intervals: interval relations, melody, consonance and dissonance, harmony.

In the same manner we may tease out the factors of *intensity;* that is, all phases of loudness and various aspects of volume, as measured by the amplitude of the wave. The measurement of amplitude of sound wave becomes exceedingly intricate because it is tied up with so many other complicated factors, such as timbre, pitch range and absolute intensity. However, readings of that kind

enable us to deal with such phenomena as the following:

TABLE II

INTENSITY FACTORS IN A MUSICAL PHOTOGRAM (IN TERMS OF AMPLITUDE OF SOUND WAVE)

I. Intensity (loudness): absolute, relative, uniform.
II. Deviations from mean intensity:
  (1) Erratic deviations of all kinds.
  (2) Progressive deviations: crescendo, diminuendo, swell, circumflex, etc.
  (3) Periodic deviations: vibrato, tremolo, innervation pulsations, all forms of accent or rhythmic stress.
  (4) Attack and release.
  (5) Forms of transition: voiced or non-voiced, silence.

In a similar manner we tease out from the record phenomena of *time*. There is a time line in units of .01 sec., as in Figure 1, which may be read in tenths of a unit, making thousandths of a second in terms of which the duration of any voiced phonetic element can be determined with accuracy.

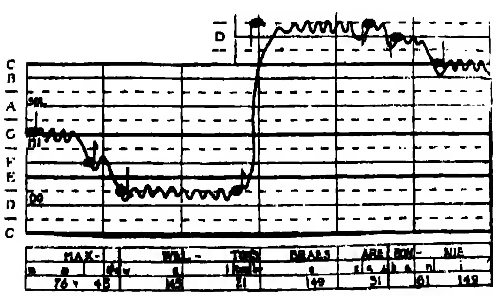


FIG. 3. *Annie Laurie* AS SUNG BY McCORMACK. [FROM METFESSEL.]

Figure 3 is an example of the scientific musical staff which we have adopted to represent the combined pitch and time factors. Here the phonetic elements and the actual words are recorded on parallel lines. Above these are the demarcations of time for each syllable in a hundredth of a second. On the same legend are the demarcations of measures, phrases and one-second units. Tenths of a second are shown by the dashes and blanks on the broken score lines. This scientific score then combines the essential pitch and time aspects of a song on a musical staff which will enable any musician to see and "hear out" the exact character of the musical performance in these two respects. Among the time factors that may be of musical significance are the following:

TABLE III

TIME FACTORS IN A MUSICAL PHOTOGRAM (IN TERMS OF DURATION OF VIBRATION)

I. Mean time: absolute, relative, tempo.
II. Deviations from mean time:
  (1) Erratic deviations.
  (2) Artistic deviations: accelerando, retardendo, hold, staccato, legato, etc.
III. All temporal aspects of rhythm.

Finally and most complicated of all are the data which come from the wave form and furnish the *timbre* or tonal quality. The significance of wave form may be shown effectively by a comparison of the wave form in two well-known instruments and a speaking voice. The middle curve in Figure 4 is the photograph of a tuning fork tone. It represents a pure tone; all other wave forms must be interpreted in terms of the relationship to that form. The top curve is a photograph of the sound wave from a trombone, rich as indicated by the complicated contour of each wave. The bottom curve shows sound waves from a speaking male voice.[1]

FIG. 4. WAVE FORMS ILLUSTRATING DIFFERENCE IN TIMBRE OF TONE.

[1] These particular pictures were not taken for the purpose of harmonic analysis and are adequate only for pitch and time measurements.

These pictures impress the fact that one can see directly the character of a musical tone in the form of the sound wave. The human voice, both in singing and speaking, is just another instrument. The photographic reproduction of the sound has a far more faithful detail than even the most musical ear can hear and with the technique now available any form of sound wave may be analyzed into its component partials representing overtones or, if the partials are known, the wave may be reconstructed. In other words, we now have a relatively complete technique for the preservation and interpretation of tonal qualities. The best work that has been done on this subject within the last few years is in the scientific laboratories of the American Bell Telephone and the United States Bureau of Standards. Artistic and even unartistic expression of tone quality may be represented in the wave form so that we may reconstruct a tone, the wailings of a lute or a primitive language from this faithful representation of the sound medium.

The scope of application to timbre in music and speech may be exemplified by such features as the following:

TABLE IV

TIMBRE FACTORS IN THE MUSICAL PHOTOGRAM (IN TERMS OF THE FORM OF THE SOUND WAVE)

I. Pure tone.
II. All forms of noise and unorganized tone.
III. Tonal clangs (harmonic analysis in terms of number, prominence and distribution of overtones) *e.g.:*
   (1) Vowel and other voiced phonetic elements.
   (2) "Character" of all voices and instruments.
   (3) Artistic effects in tone quality.
   (4) Faults in tone quality.
   (5) Tonal fusion.
   (6) Sonance.

This all sounds mechanical and over-simplified; but it is marvelously beautiful and useful that science can thus bring simple order and law to bear on the understanding of our tonal manifold and the control of it. Frequency, amplitude, duration and form of the sound waves—these are the four kinds of material of which the whole structure is built. In terms of these the stupendous radio wonders in the transmission of sound have been produced. In terms of these the composer, the interpreter and the performer express music and speech. It is now only a matter of patient workmanship for the future inventor to make a synthetic human voice automaton capable of speaking in languages, playing upon the whole gamut of emotions in vocal expression and even of executing artistic effects not yet attainable through the voluntary performance of the singing or speaking artist.

From this limitless field of possibilities thus opened let me present only two illustrations of the use of the photo-phonographic method: the first, in the measurement of a specific type of expression of tender feeling; the second, the anthropological use of the method in collecting primitive music.

II

One of the most striking impressions one gets from the objective study of beautiful music is that art consists primarily in pleasing deviations from the regular. In music and speech pure tone, true pitch, exact intonation, perfect harmony, rigid rhythm, even touch and precise time play a relatively small rôle. They are mainly points of orientation for art and nature. The unlimited resources for vocal and instrumental art lie in artistic deviation from the pure, the true, the exact, the perfect, the rigid, the even and the precise. This deviation from the exact is, on the whole, the medium for the creation of the beautiful—for the conveying of emotion. That is the secret of the plasticity of art. The exact is cold, restricted and unemotional; and, however beautiful in itself, soon palls upon us.

One of the countless media for the expression of tender emotion by deviation from the regular in pitch and intensity in music and speech is a sort of quiver called the *vibrato*. In musical literature on theory and practice there is one baffling confusion as to the nature of the vibrato and its esthetic value. Several research men have recently worked on this problem in the Iowa laboratory. Volumes VIII, IX and X of the Iowa Studies in Psychology contain articles bearing on this subject. Dr. Metfessel, National Research Council Fellow in psychology, is now preparing an elaborate monograph, laying scientific foundations for the determination of the nature and function of the vibrato in terms of experimental data. He treats such topics as the determination and classification of types of the vibrato; causal relations in terms of mental, neural and muscular factors of control in the production of the vibrato; relative prevalence in trained and untrained singers—young and old, primitive and cultured; the difference between artificial and natural vibrato; its relation to other forms of periodicities; norms of beauty in its form; the significance of its emotional and automatic control; methods of acquiring, modulating, refining and inhibiting the vibrato; its relation to temperamental and other personal traits; its relation to the various qualities of emotion; and many other psychological, musical, anthropological and educational problems involved in this medium for the expression of tender emotion. Each issue is dealt with by rigid objective methods of laboratory procedure.

Dr. Schoen was the first to analyze and measure the vibrato. On the basis of measurements on the recorded singing of Aldah, Destinn, Eames, Gluck and Melba he demonstrated that the vibrato is a synchronous oscillation of pitch and intensity of tone at the rate of about six vibrations per second. He measured separately the pitch and the intensity factors and found them to synchronize. While there is an error in his first measurements of pitch, this putting of the vibrato in black and white with mathematical precision should mark an epoch in musical theory and practice on this subject.

Generalizing from a vast variety of concrete data at hand we may define the vibrato in calm and beautiful singing as a synchronous pitch and intensity oscillation, ordinarily at the rate of from five to eight oscillations per second, in which perhaps the most beautiful effect is obtained when the pitch oscillation does not exceed one fourth of a tone and the intensity oscillation is as barely perceptible as the pitch oscillation and both take the form of a smooth sine curve.

Countless descriptive features may be added to such a definition for specific purposes, and qualifications may be added as new information accrues. The point is that we are now enabled to define, describe, measure and control such a subtle aspect of the expression of tender emotion as the slightest change in the character of a vibrato. The fundamental facts of the vibrato may be represented symbolically, as in Figure 5, which indicates that in good calm singing there is a synchronous and graceful oscillation in pitch and intensity of the tone as stated in the definition.

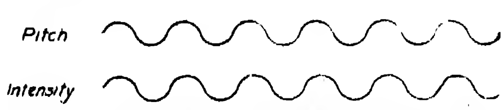


FIG 5. A SCHEMATIC REPRESENTATION OF THE VIBRATO.

Dr. Kwalwasser, studying a large number of cases by the photographic method, found the vibrato present in 93 per cent. of his samples of cases in

well and moderately trained singers and 27 per cent. in untrained adults. He found that the vibrato is ordinarily parallel (that is, when the pitch rises the sound increases in intensity, as in Figure 5); but all gradations from this to the opposite vibrato, which is the reverse of the parallel, may occur. He also found cases of a pure pitch vibrato and of a pure intensity vibrato. His studies centered about the effect of placement, voice quality, pitch register, voluntary control and the development of the vibrato in children.

Dr. Simon refined the technique of measurement and determined the degree of reliability in consecutive sound waves in voices and instruments, an item which it is necessary to know in establishing periodicities in musical tone—an excellent example of the mastery of fine details.

One of the problems is to set up norms for recognizing good singing involving the vibrato. Figure 3 is from Metfessel's publication of the singing of Annie Laurie, giving a sample of McCormack's singing. (The entire song as rendered by McCormack and by Wells has been published.) An adequate collection of actual renditions of this kind will be the basis for determining what we may call good practice, which is the first step in the effort to determine a large number of component factors that operate to make the thing beautiful. The briefest illustration of this kind is shown in Figure 6. These samples are transcriptions from photographs of phonograph records, the phonograph record being entirely satisfactory for the study of pitch. The pitch vibrato is shown for what was supposed the least emotional of the words in the song, "and" in the twelfth measure ("And 'twas there that Annie Laurie . . ."). In these graphs the vertical division of the staff is in terms of half tones and the horizontal units in terms of tenth of a second. The graph shows exactly how each singer rendered this tone in pitch and duration. The vibration frequency indicated at the left shows what the true tone should have been for the prevailing pitch. The notes are not attacked or sustained in true pitch, but these again are often the plastic media for artistic effects and should not always be counted as wrong. Anna Case furnishes an illustration of artistic license in time in that she holds this note, which is within her favorite register and has a beautiful vibrato,

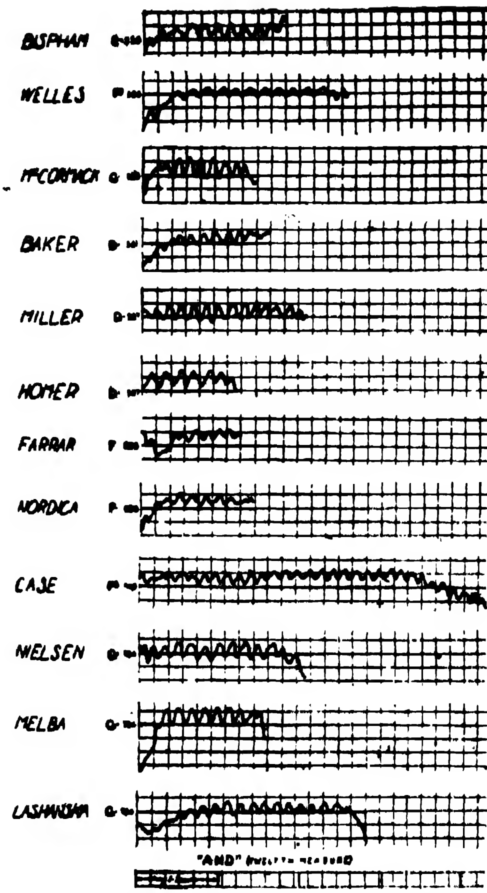


FIG. 6. THE VIBRATO OF TWELVE WELL-KNOWN SINGERS.

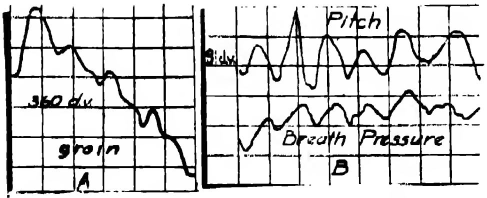


FIG. 7a. VIBRATO ON A FALLING INFLECTION.
FIG. 7b. VIBRATO ON A SUSTAINED PITCH IN SPEECH. [FROM GRAY.]

quite regardless of the time and tempo of the song. Each singer has an individual way of attacking, sustaining and releasing the note, but all have the vibrato. No one can hereafter say that it is really bad form at the present time to sing with a vibrato, unless he is willing to say that these twelve singers selected at random from good singers are in bad form. The intensity phase of the vibrato is not shown in these graphs, although it is present in every case and is perhaps fully as significant as the pitch oscillation.

We know nothing yet about the evolution and the heredity of this phenomenon, but are accumulating data in regard to its development in children. Dr. Metfessel now has records on the development of the vibrato in about three hundred cases of children ranging from five to eighteen years of age. These show that the vibrato may come in at different ages and under vastly different conditions, in different forms and at different rates.

Professor Wagner is attempting to analyze the different forms of the vibrato, particularly with reference to the teaching of the production of the vibrato and its modulation to conform to most natural methods of production and the most agreeable type. He takes a little child that has no vibrato and then trains with a specific theory in mind and records from time to time the artistic development and progressive automatization of that type. In all these and various other studies now in progress the technique is comparatively simple and always objective.

Dr. Gray has studied the presence of the vibrato in emotion and speech and finds it quite prevalent. In speech it is not as conspicuous because words are spoken with rich inflection and are seldom sustained at any pitch level. He has, however, found that the vibrato frequently rides on a rising, falling, or circumflex inflection, as in Figure 7a. Figure 7b shows a speech vibrato in a sustained vowel sound. There are, however, other periodicities in speech sounds which are more important than the vibrato, for example, one at the rate of about twenty per second as shown by the contour of the curve in Figure 8, which is a record of breath pressure, probably synchronizing with intensity of tone, in singing.

FIG. 8. PERIODICITIES IN THE BREATH PRESSURE DURING THE SUSTAINING OF A TONE. [FROM METFESSEL.]

Dr. Travis, working with stutterers, has found examples of vibrato in their speech.

In addition to these objective measurements of the expression of the vibrato we must carry a variety of supplementary techniques for the purpose of determining the causes, conditions and relations to nervous disorders. Thus, the person singing with a vibrato is observed

FIG. 9. PHOTOGRAPH OF THE ACTION CURRENT SHOWING THE RATE OF INNERVATION AND A PERIODICITY OF TWELVE CYCLES PER SECOND IN THE TONUS OF A MUSCLE. [FROM TRAVIS.]

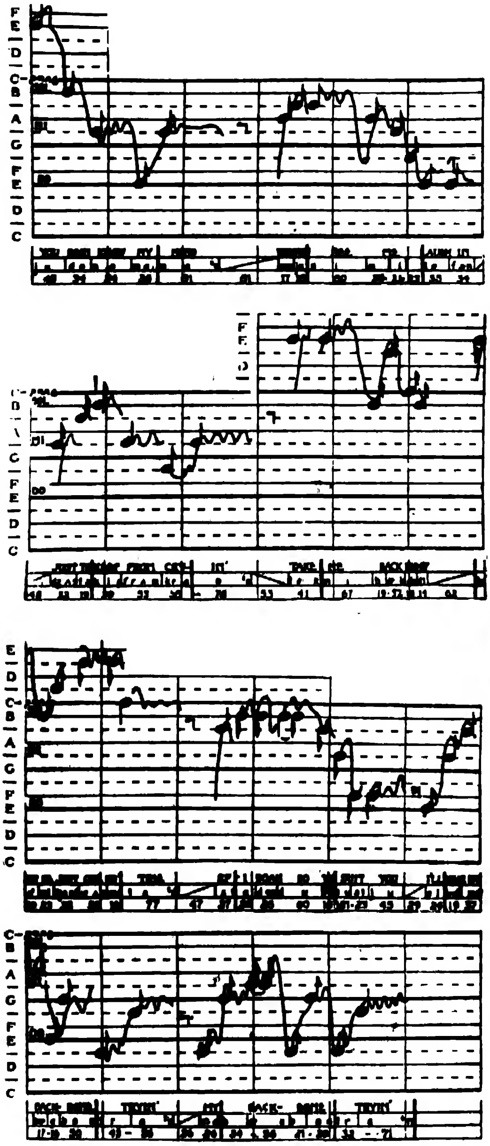


FIG. 10. ONE OF THE NEGRO "BLUES" AS SUNG IN THE CORNFIELD. (THE APPARENT ADDITIONS AT THE TOP OF THE STAFF CORRESPOND TO LEDGER LINES IN ORDINARY MUSICAL NOTATION.) [FROM METFESSEL.]

with the fleuroscope through which the various types of action of the diaphragm, the vocal cords and the resonance cavities may be observed directly in the normal functioning. When more detailed record is needed and when measurement is desired we may resort to the X-ray picture. To supplement the moving picture of the sound wave we get a moving picture of the action of the diaphragm or a particular set of muscles in the vocal cords, the tongue, etc. After finding this, Dr. Metfessel looked back upon

FIG. 11. NEGRO SINGING, "I HEARD THE VOICE OF JESUS SAY." [FROM METFESSEL.]

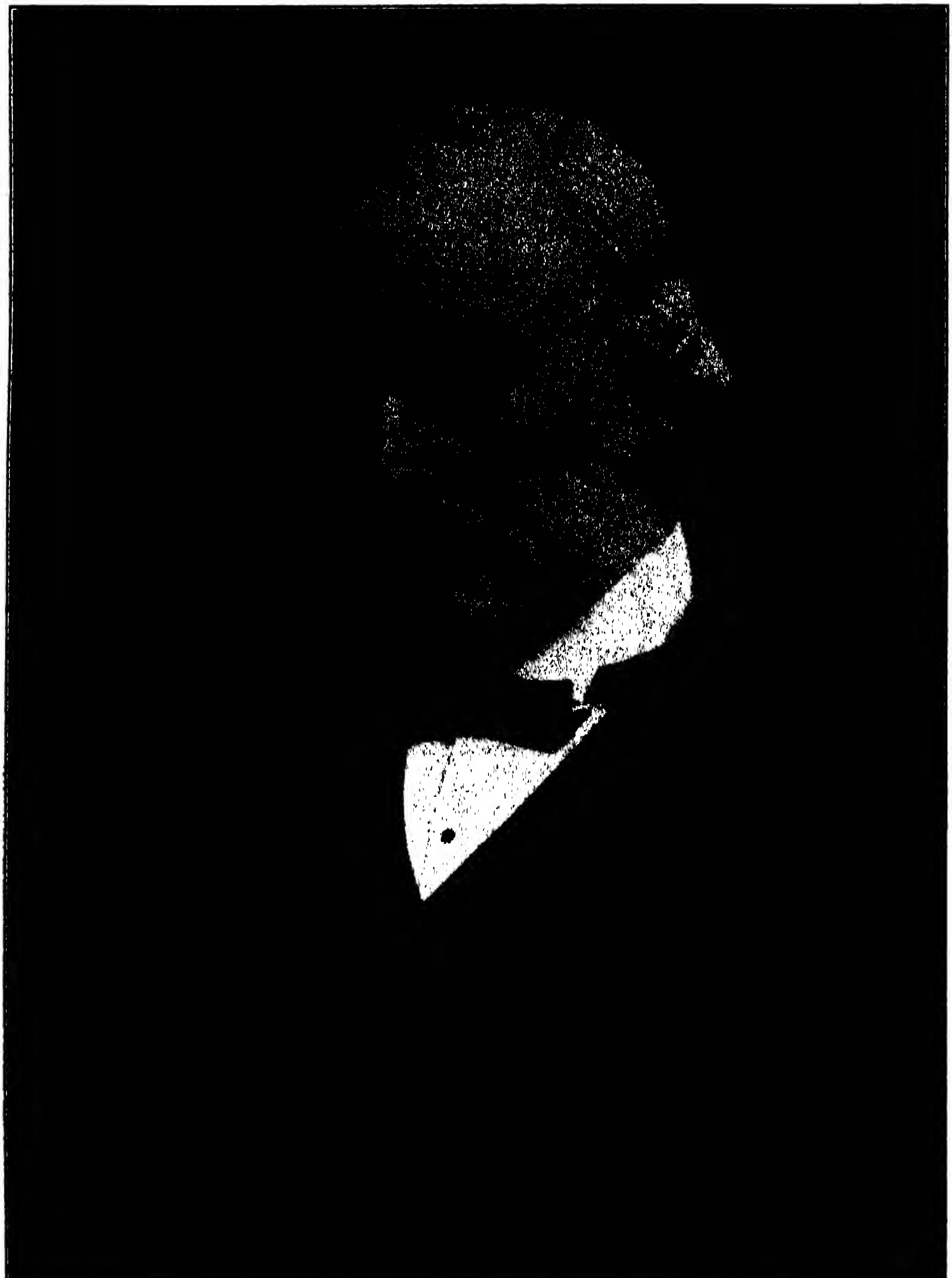
some of our published records of singing and found that these oscillations show up in the details of a photogram of pitch. Figure 9 is a similar illustration of the effect of rate of innervation; this time through the measurement of action current which Dr. Travis is using in studying the tonus of muscles. Besides this basic periodicity there is evidence of other periodicities, some of much higher frequency and others of lower frequency, probably indicating interference in the innervation of cooperating musculatures. Here, as in the famous illustration of the growing blade of grass, if one had all the facts about the vibrato, he would have a wonderful knowledge of several sciences.

III

My personal interest in phonophotography dates from the time when the Smithsonian Institution sent its specialist in Indian music, Miss Frances Densmore, to our laboratory to have her ears certified with reference to the degree of reliability for the transcribing of phonograph records. It then occurred to me that it was possible to avoid depending upon the ear, which is quite inadequate for the purpose, and substitute a photographic method. This led to the developing of photographing of phonograph records, and that in turn to the direct photographing from a musician's performance.

To demonstrate the availability of this method for anthropological field work, we have, in cooperation with the University of North Carolina, under a grant from the Laura Spelman Rockefeller Foundation, made a collection of Negro songs sung in the natural setting. Dr. Metfessel has prepared and is publishing a volume of these in the new musical terminology illustrated in Figure 10.

For the purposes of collecting the camera is vastly superior to the phonograph in that it furnishes a permanent record, giving vastly finer details than can be heard from the phonograph, and is transcribable and measurable with a high degree of precision. Figure 11 is a picture of a Negro singing a spiritual after he had "warmed up" into ecstasy. His singing before that was very different. Such supplementary data are of anthropological value in preserving the atmosphere of the song. Indeed, the collector in the future will want not only the phonophotograph, but also some form of phonograph record and a moving picture of the musician in action, together with very accurate phonetic transcripts of words.



LORD LISTER

The centenary of the birth of Lister, which occurred on April the fifth, has been celebrated by the Royal College of Surgeons and at Westminster Abbey. It is said that Lister's discovery of antiseptic surgery saved more lives than were lost in all the wars of the century since his birth.

THE PROGRESS OF SCIENCE

EDITED BY DR. EDWIN E. SLOSSON
Director of Science Service

LEGISLATION AGAINST THE TEACHING OF EVOLUTION

A SURVEY of the legislative season just ended discloses what appears to be an utter collapse, for the time being at least, of the drive to banish the teaching of evolution from American schools, widely heralded after the Dayton trial and the death of William Jennings Bryan. During the winter and spring of 1926–27 no less than twelve state legislatures had anti-evolution bills brought before them, and all twelve have adjourned without the passage of a single one of the measures.

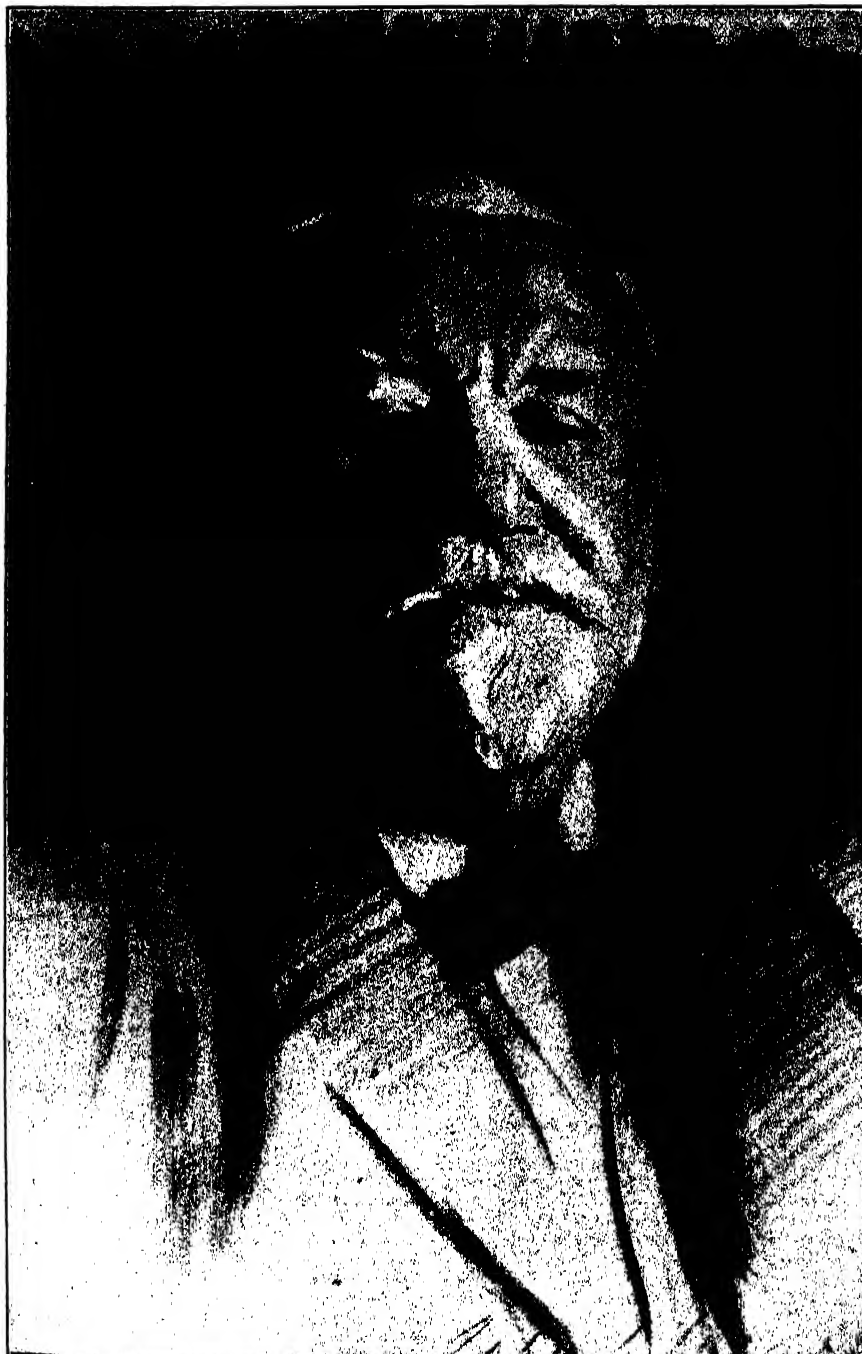
In six of the states, California, Delaware, Minnesota, New Hampshire, North Carolina and North Dakota, the bills did not even get to the floor of the house, but were disposed of in committee, usually by decisive or even unanimous votes. In Missouri, which was declared in advance by the fundamentalist forces to be a pivotal state, the bill reached the house and was there rejected by the margin of 82 to 62. In West Virginia and Oklahoma anti-evolution measures were defeated by house votes of 57 to 36 and 46 to 30, respectively.

The fight was begun very early in Arkansas and carried on aggressively by the proponents of the bill, and it was expected that this state would pass over into the Tennessee-Mississippi class so far as freedom of teaching was concerned. But it turned out otherwise, for after passing the lower house by a very close margin (three votes, according to one report; one vote, according to another) it was rejected in the senate by an overwhelming aye-and-nay vote. A part of the clergy in Arkansas are reported to be very angry over the outcome of the contest, and to have declared war on all members of the legislature who are known to have voted against the bill.

In only two states has the proposed repressive legislation survived even in an attenuated form. In Alabama, a bill on the Tennessee model was introduced during January and remained sleeping in committee until, in March, the legislature adjourned until June 7. What will happen then no one will undertake to prophesy. In South Carolina the bill likewise slept until the closing hours of the session, when it was reported out by the committee, without recommendation; in order, its author stated, that it might remain on the calendar until the next session.

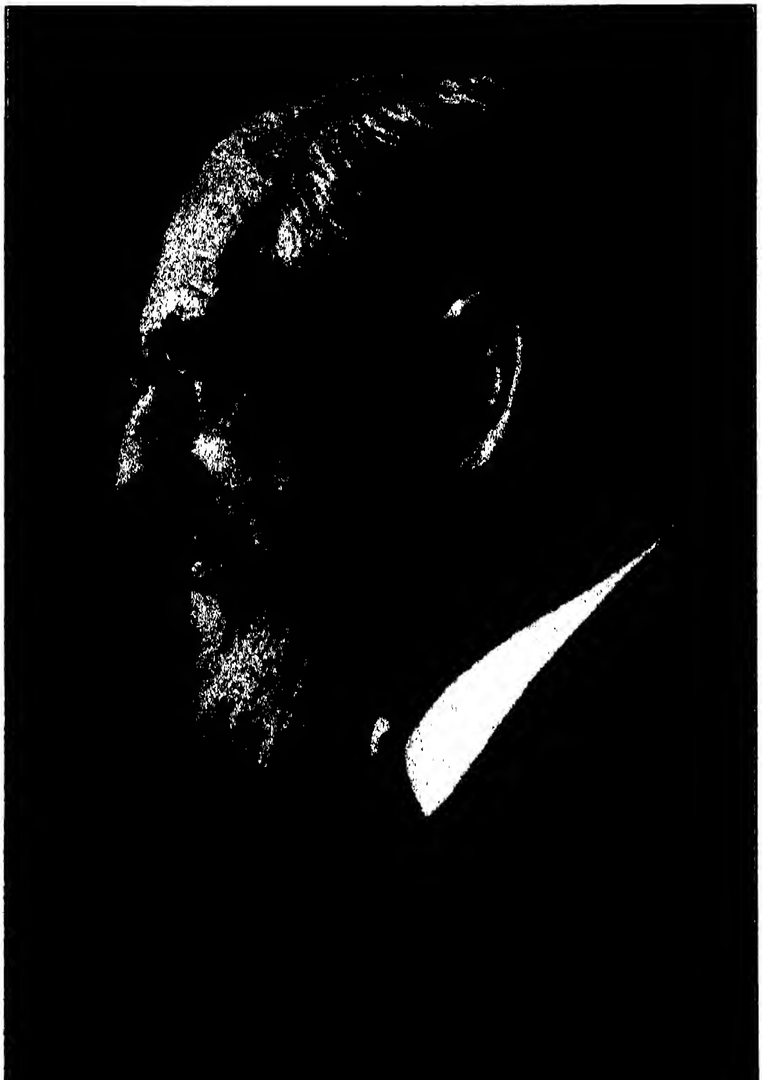
The Florida legislature meets much later in the year than do the law-making bodies of the other states; it convened early in April. It is taken for granted that some one will introduce a bill at Tallahassee, but up to the present no anti-evolution proposal has appeared. Some years ago the legislature of this state went on record with a resolution condemning evolution, but this does not have the force of law, and is steadily ignored by teachers in Florida schools and colleges.

Even the two states that have enacted anti-evolution laws can hardly be counted as completely gained by the fundamentalist forces. In handing down its decision on the appeal of the Scopes case, the Tennessee State Supreme Court justices gave three distinct versions of their ideas of the meaning of the law, which are interpreted by competent authorities on constitutional law to mean that one can teach about anything he



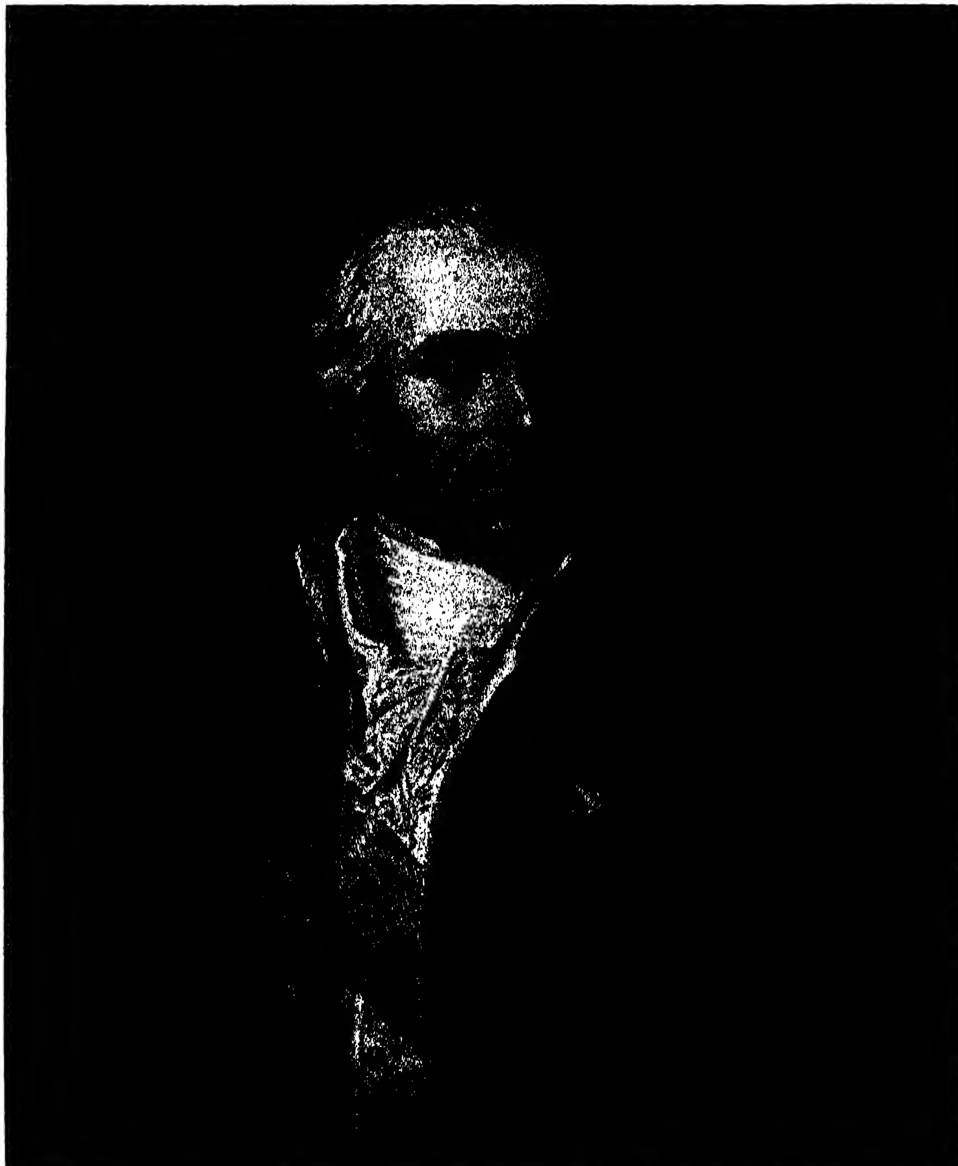
CHARLES SPRAGUE SARGENT

IN WHOSE DEATH AMERICA LOSES ONE OF ITS LEADING MEN OF SCIENCE. DR. SARGENT WAS FOR FIFTY-FIVE YEARS DIRECTOR OF THE ARNOLD ARBORETUM AND FOR NEARLY AS LONG ARNOLD PROFESSOR OF ARBORICULTURE AT HARVARD UNIVERSITY. THE PORTRAIT IS FROM A DRAWING BY JOHN S. SARGENT.



WILLIAM HEALEY DALL

DISTINGUISHED FOR HIS WORK ON RECENT AND FOSSIL MOLLUSKS, WHO HAS DIED AT THE AGE OF EIGHTY-TWO YEARS. DR. DALL WAS CURATOR IN THE U. S. NATIONAL MUSEUM FOR FIFTY-EIGHT YEARS. IN THE DEATHS OF PROFESSOR SARGENT AND OF DR. DALL, AMERICA LOSES TWO VERY GREAT NATURALISTS SUCH AS IT IS NOT LIKELY AGAIN TO PRODUCE.



LAPLACE

THE GREAT FRENCH MATHEMATICIAN, THE CENTENARY OF WHOSE DEATH IS NOW BEING CELEBRATED AT ALMOST THE SAME TIME AS THE TWO HUNDREDTH ANNIVERSARY OF THE DEATH OF NEWTON. LAPLACE'S "MECHANIQUE CELESTE" IS THE MOST NOTABLE SUCCESSOR OF NEWTON'S "PRINCIPIA." HIS NEBULAR HYPOTHESIS WAS PROPOSED IN HIS "SYSTEME DU MOND," PUBLISHED IN 1796. THE PORTRAIT IS FROM AN ENGRAVING AFTER A PAINTING BY NEGEON.

pleases in Tennessee so long as he does not come out flat-footed for atheism or philosophic materialism. In Mississippi the law is in force, but has not yet been tested in the courts.

Action by the Education Association of the Methodist Episcopal Church of the South, in condemning the anti-evolution legislative program, was hailed as highly significant by educators and interested persons everywhere. The resolution was introduced by the president of Duke University, and only two delegates voted against it. Prominent Southern Baptist churchmen have also gone on record as opposed to legislative restrictions on teaching.

Checked in their program of stopping the teaching of modern science by legislative action, the fundamentalists have adopted a new program, which may become the more formidable because it is so widely diffused and because it deliberately appeals to the willingness of certain types of persons to play the spy and informer. The "Supreme Kingdom," founded by Edward Young Clark, formerly prominent in Ku Klux Klan circles, announces as part of its plan to operate through small local organizations, endeavoring to prevent the employment of teachers who believe in evolution and to prevent the election of school officials who will hire or back them.

THE ANTIQUITY OF MAN IN AMERICA

PRIMITIVE man lived in America at a vastly earlier time than is believed by most scientific men if the evidence gathered by J. D. Figgins and Harold J. Cook, of the Colorado Museum of Natural History, is valid.

Instead of dating back only some 8,000 to 25,000 years, the time when most archeologists and anthropologists say the Indian came to America from Asia, these human relics, because of their association with extinct animals and geological deposits of known antiquity, are assigned to the geological period that scientists know as the Pleistocene. That was the time of the great Ice Age when northeastern America was periodically covered with an immense glacier and when prehistoric elephants and mastodons roamed the land. It was from 25,000 to a million years ago.

From three localities have evidences of human antiquity on the American continent been obtained: Frederick, Tillman County, Okla.; Colorado, Mitchell County, Texas, and Folsom, Union County, New Mexico. Investigations at the site of the Oklahoma discovery have just been completed and the findings have not yet been announced.

From all three sites, arrowheads have been unearthed in close association with extinct animals. Along Lone Wolf Creek, near the town of Colorado, Texas, flood waters exposed the bones of an extinct species of bison, and while large blocks of the earth in which they were embedded were being removed for transportation to the museum, three arrowheads, totally unlike those in any known collections, were found beneath a nearly complete skeleton. The arrowheads were of grayish flint, thin and not notched.

At Folsom, New Mexico, fossil bones were discovered at the extraordinary altitude of 7,000 feet, and among the fossil bones were found two arrowheads similar to those found in Colorado. The bones were identified as those of three hitherto unknown and extinct species of bison and an ancient deer-like animal. Discovery of this deposit was made through the interest and observation of Fred Howarth and Carl Schwachheim. An exact geological determination of the

THE LEANING TOWER OF PISA

THE CAMPANILE OF THE CATHEDRAL OF PISA IS ONE OF THE FINEST EXAMPLES OF ROMANESQUE ARCHITECTURE; BUT IT IS BEST KNOWN FOR ITS LEANING POSITION. IT WAS FIFTEEN AND A HALF FEET OUT OF THE PERPENDICULAR IN 1829, AND THE DEPARTURE IS NOW ABOUT A FOOT GREATER. THE FOUNDATIONS ARE NOT MORE THAN TEN FEET DEEP, AND THEIR CIRCUMFERENCE IS ONLY THAT OF THE TOWER. IT IS THOUGHT THAT THE TOWER ASSUMED ITS OBLIQUE POSITION WHILE IT WAS BEING BUILT. ITALIAN ENGINEERS ARE NOW CONSTRUCTING A CEMENT SOCKET UNDER THE TOWER TO PREVENT FURTHER SINKING.

age of the deposit has not been made, but it is believed to be late Pleistocene.

The locality richest in evidences of ancient man in America is near Frederick, Oklahoma. F. G. Priestly read an article by Mr. Cook, calling attention to the possibility of ancient man having existed in America. He realized that arrowheads and stone-grinding implements that were being uncovered from time to time by steam shovels in a sand and gravel pit might be of some interest. With the cooperation of A. H. Hollman, owner of the gravel pit, he reported the discovery to Mr. Cook, who, with Mr. Figgins, promptly investigated. There they found three distinct layers of deposits and in a very short time two arrowheads and some seven metates, primitive grinding instruments, were excavated from the pit. Those working in the pit remembered other worked stones that had, before realization of their significance, been thrown away. With the artifacts, as in the other cases, remains of extinct animals were found, and eight feet above the level at which the grinding stones nearest the surface were discovered, there were found remains of the mammoth, including numerous teeth. This is considered strong evidence of the great antiquity of the arrowheads and the metates. A representative of the Colorado Museum of Natural History is now located at the gravel pit to collect and preserve any other such finds.

Inspection of the arrowheads discovered shows them to be primitive, and yet the man who made them must have progressed considerably in culture, according to Mr. Figgins. Mr. Cook has made a careful study of the geology of the three places where discoveries were made and he has expressed himself as "convinced of contemporaneous association" of the artifacts with Pleistocene deposits and animal remains "surprising as such a culture at that time may seem."

ADVANCES IN TELEVISION

Described as one of the greatest triumphs in the history of methods of communication, the television process of the American Telephone and Telegraph Company, first exhibited in action between New York and Washington on April 7, is the product of many minds working together in the Bell Laboratories in New York under the guidance of Dr. Herbert E. Ives. Despite the elaborateness of the apparatus, television depends essentially upon the fact that a film of potassium metal in a vacuum tube can be made to give a small electric current when light shines on it. This is the photoelectric cell.

In previous methods, the subject, whose visage is to be transmitted, is flooded with brilliant light, and a lens picks up the illumination and focuses it on a small photoelectric cell. In the new method, by the idea of Dr. Frank Gray, the subject is illuminated with a tiny moving spot of light, which is picked up by a battery of large photoelectric cells—the largest yet made. The result is the most successful transmission of the actual view of the human face that has yet been achieved.

As seen on the small receiving screen, the scene looks like a halftone two inches high, printed in the pink sheet edition of a daily paper—except that it has come to life. Most newspapers print photographs in what is known as halftone—small dots spaced 50 to 60 to the inch and blended by the eye into a continuous picture, a process, incidentally, which was the invention many years ago of Frederic E. Ives, the father of Herbert E. Ives, who is immediately responsible for the new process.

In the television receiver, the picture is also made up of fifty eye-blended rows

of light and dark, which appear pink because the light in which they are painted comes from glowing neon gas—a rare element found in the atmosphere. When two metallic electrodes are sealed into a glass tube from which all air has been exhausted, but which contains a little neon, and an electric current is passed through, the gas glows with a pinkish light. Unlike the ordinary electric lamp with a filament of tungsten, which continues to glow for an instant after the current has been disconnected, the neon light goes on and off as instantaneously as the current itself.

To television a speaker's face from Washington to New York, for example, the light starts from the carbons of an automatic arc lamp. In front of the lamp is a disc with fifty holes around its edge in a spiral, each hole a little nearer the center than the one before it. A lens projects an image of the holes out into space, just as the lens of a movie machine projects an image of the moving film on to the screen, but in the television device the screen is the subject's face. And just as the movie film travels through the machine so fast that the single pictures are not seen, but are combined together by the eye into a continuous picture, so does the rapidly moving disc, containing the holes, move so rapidly that the fifty holes, each one a little lower than the one before it, sweep across the facial screen in less than a fifteenth of a second.

Outside the light from the arc, shining through the holes in the disc, the subject is in semi-darkness. In front of him are three photoelectric cells, the eyes of television. They turn the light into electricity. The production of these cells itself is a triumph, accomplished by Dr. Ives. They are the largest that have yet been constructed. When the moving finger of light, a fiftieth of an inch in diameter, sweeps across the face, it encounters the light-colored flesh; light is reflected to the sensitive photoelectric cells. By means of amplifiers like those used in radio stations, the photoelectric cells' tiny current, the electrical counterpart of the light, is magnified thousands of times. And when the spot of light reaches a dark part of the face—the pupil of the eye perhaps—and no light is reflected, no current flows from the cells to the amplifiers.

Thus, the lights and shades of the face are transformed into a varying electric current, just as the ordinary telephone transmitter transforms the sounds of the voice into a pulsating current. It travels over the telephone lines for hundreds or thousands of miles, or else on the radio carrier waves for even greater distances. The receiving end picks up the current, amplifies it some more to make up for any losses in transmission, and connects it to the receiver, with its neon tube.

The variations in current are translated by the neon tube back into variations of light. But the tube shows an extended surface of light—an inch or more square—with no semblance of a picture of a face or anything else. Here the revolving disc again plays a part. A disc the exact duplicate of the one at the sending end revolves in front of the neon tube.

If the spot of light in the sending apparatus is shining on the bright flesh, the receiving screen shows a corresponding bright area through the hole. And then as the sending light spot moves to the dark pupil of the eye of the subject, the neon ceases glowing and the screen shows a dark spot. As the spot moves to another white portion, such as the bridge of the nose, the neon again shines through the hole, which has also moved. The receiving disc, like the transmitting one, moves so rapidly that the light appears to the person observing as a continuous surface, blended into a motion picture of the sending scene.

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SKELETAL RECORDS OF MORTALITY

By Professor T. WINGATE TODD

HAMANN MUSEUM, WESTERN RESERVE UNIVERSITY

INTRODUCTION

THERE is a profound difference between the potential duration of life and the action duration of life. The former holds for all humanity in all periods of man's history, but the latter is modified by very many factors arising from the environment. In a recent paper Pearl has differentiated clearly between these two views of the duration of life.[1] He gives good evidence for the presumption that potential duration of life is definite and unchangeable: it is a function of bodily organization. It is seen in all forms of life: after a certain definite period death is a natural consequence whether the living thing be plant or animal, invertebrate or vertebrate, cold blooded or warm blooded, bird or mammal. Rarely, however, is this full potential span of life realized: some environmental factor steps in to terminate life before its natural course is run.

So far as humanity is concerned, Karl Pearson, many years ago, analyzed the mortality curve for England[2] and demonstrated that it is a very complex curve of several components, best conceived as curves of death specially related to the successive periods of life. Thus Pearson separated off curves of infantile death, of death in childhood, in adolescence, in middle age and in senility (Fig. 1). In a fascinating metaphor the author represents Death as attacking his victims in divers manner as they cross the bridge of life. Five deaths, variously armed, take toll of humanity: the bones of its ancestry for the baby, a machine gun for the children, an arrow for the adolescent, a blunderbuss for the middle-aged and a rifle for the full of years. Death carries off in old age nearly one half the human beings of modern days. This is the death "apart from the selection of infancy, the danger of infectious disease in childhood, and of excess or accident in youth or later life." The fire of the middle age Death is "slow and scattered and his curve of destruction a very flat-topped one." This plateau of the middle age mortality curve is significant: we shall find it quite evident in all the studies to be presented in this paper.

More philosophically but none the less realistically Conrad has portrayed old age death characteristic of modern days in creatures who "are forgotten by time, and live untouched by years till death gathers them up into its compassionate bosom: the faithful death that never forgets in the press of work the most insignificant of its children."[3]

The actual duration of life as exemplified by different peoples in successive periods of the existence of humanity must always exercise a fascination over

[1] Pearl, R., 1926, "Span of Life and Average Duration of Life," *Natural History*, Vol. [illegible], pp. [illegible].

[2] Pearson, K., 1897, "Chances of Death," London and New York, pp. 1–41.

[3] Conrad, J., 1896, "The Idiots. Tales of Unrest." London, p. 57.

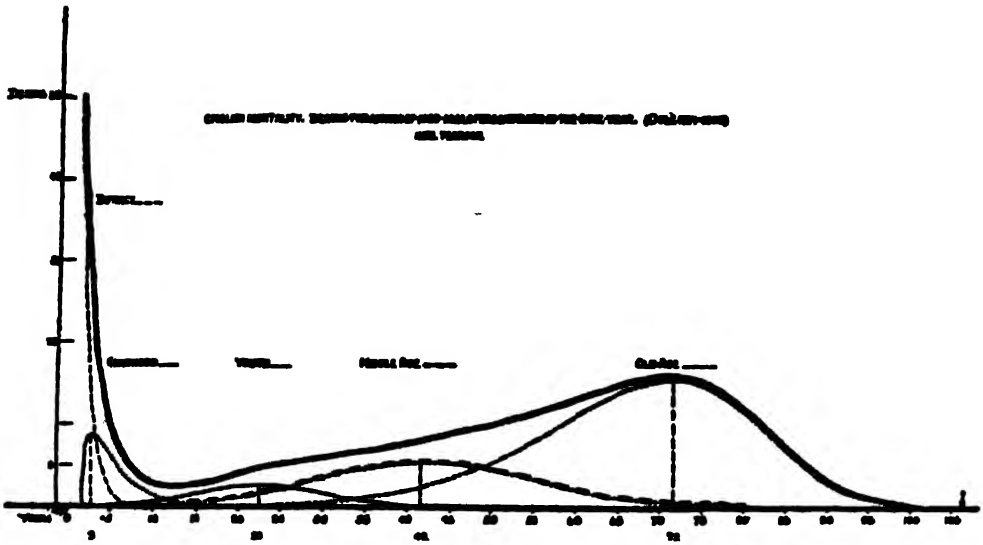


FIG. 1. ANALYSIS OF THE CURVE OF DEATH OF 1,000 MODERN ENGLISH MALES. BY KARL PEARSON. NOTE THE PEAKS OF MORTALITY IN INFANCY, CHILDHOOD, ADOLESCENCE, MIDDLE AGE AND SENILITY. THE FLAT-TOPPED CURVE OR PLATEAU OF MIDDLE AGE DEATH IS TO BE SEEN IN ALL SUCCEEDING FIGURES.

us. Many attempts have been made to study the problem. For modern civilized races there are data available which make this study precise. But for uncivilized and for ancient peoples few records exist. The Corpus inscriptionum latinarum of the Berlin Academy used by Macdonell[4] is perhaps the best of the ancient records, but even these records fail in their accuracy as the potential life period wears towards its natural close. Most other records consist of contemporary general statements which are, of their very nature, biased or refer more particularly to a restricted portion of the community. Or the impressions may be culled even more vaguely from the scant records of the ages at death of a few more notable persons of the time. The only way in which a correct assessment can be made is by wringing the secret from the bones themselves left immutable by time in the grave.

To this end we have addressed ourselves over a long period of steady and persistent work, using for this purpose the ever-increasing collection of material in the Hamann Museum. The observations recorded in this paper are founded upon the standards derived from this material.

METHOD OF INVESTIGATION

That time leaves its impress upon the skeleton is well recognized and it is usual to describe a skeleton as that of a child, an adolescent, an adult or a senile person. Beyond this rough discrimination it has hitherto been impossible to advance because of insufficient data. The singularly fortunate position of the anatomical laboratory of Western Reserve University has enabled us to progress further with assurance in the identification of age of skeletons. Ever since 1912, the policy of retaining intact the skeletons of all cadavera delivered to the medical school, together with the record of their age, among other valuable and essential data, has placed us in a unique position. At the time of writing this collection numbers some 1,400

[4] Macdonell, W. R., 1913, "On the Expectation of Life in Ancient Rome, and in the Provinces of Hispania and Lusitania and Africa." *Biometrika*, Vol. 9, pp. 366–380.

individuals of all ages and belonging to white and Negro stocks. For some years now we have been steadily publishing the results of our investigation upon the time record left imprinted on the bones, but it will require another decade to complete this work. Meantime the research has gone far enough to enable us who have the experience to indicate, with a fair probability of accuracy, the approximate age of any individual skeleton. By this statement I mean a probable accuracy of within five years distributed evenly two years on each side of the age estimate, provided that be sixty years or less. The accuracy is certainly less than this if the age is above sixty, for, toward the limit of the natural span, differentiating features become ever less pronounced and more erratic.

One can not give a full description here of all the details upon which our age estimate is based, but the general scheme is the following. Up to and including the age of twenty-five the union of epiphyses may be relied upon as an age indicator. It has been assumed, upon altogether insufficient evidence, that individual variation is so great that no real reliance can be placed upon epiphyses as an age determinant. Our quantitative studies emphatically deny this assumption. Part of this research has been published in the paper by Stevenson.[5] From twenty-five to thirty-five years the symphysis pubis gives a fair indication of age, and to the elucidation of the symphysial problem I have myself devoted a number of papers, the results of which are summarized in the one to which reference is here given.[6] Between thirty-five and fifty years changes take place in regular sequence at the articular ends of bones, at the muscular attachments and in the texture. This period has not yet been properly recorded in published form, but Graves has given, in a paper on the scapula, an adumbration of what will eventually be demonstrated.[7] At or about fifty years certain well-defined differences in texture and secondary changes on the surface of bones set in which have as yet been but lightly sketched in the papers by Graves and by myself. Suture closure has but a qualified value in this study. For white and Negro males the subject of suture closure has been adequately presented by Lyon and myself in various published articles (13).

The life history of the skeleton from adolescence to senility can be outlined in the following manner. From adolescence to the age of twenty-five years union of epiphyses is the dominant feature. From twenty-five to thirty years closure of sutures continues the tale along with the consolidation of areas, like the symphysis pubis, which possess rudimentary epiphyses. From thirty to thirty-five years the skeleton is at its prime and there is a lull in differentiation. Sutures not yet fully closed mark time, having lost their impetus to unite. During this period the muscular system and the cerebellum, the coordinating mechanism for muscular control, begin to show deterioration.[8] Such deterioration becomes indicated in the bones between thirty-five and forty-five years as an intensification of the sites of muscular attachment and as the formation of rims, not lipping, at the articular margins. The so-called muscular markings on bone are not an indication of muscular development and strength but appear when the muscular

[5] Stevenson, P. H., 1924, "Age Order of Epiphyseal Union in Man." *Journ. Phys. Anthropol.*, Vol. 7, pp. 53–93.

[6] Todd, T. W., 1923, "Age Changes in the Pubic Symphysis VII. The Anthropoid Strain in Human Pubic Symphyses of the Third Decade. *Journ. Anat.*, Vol. 57, pp. 274–294.

[7] Graves, W. W., 1922, "Observations on Age Changes in the Scapula." *Journ. Phys. Anthropol.*, Vol. 5, pp. 21–33.

[8] Ellis, R. S., 1920, "Norms for Some Structural Changes in the Human Cerebellum from Birth to Old Age." *Journ. Comp. Neur.*, Vol. 32, pp. 1–33.

system is on the downgrade, long after the time when current hypothesis would call for their maximum development. From forty-five to fifty years preparation is being made for the far greater changes occurring after fifty: the final rims are developed and the smooth and polished surface texture of earlier years begins to give place to a more granular appearance which after fifty, first in ribs and vertebrae but later spreading to all parts of the skeleton, is associated with a peculiar modification of bone substance which we describe as a cinder-like texture. Between fifty and sixty years the surface erosions progress, but from sixty onwards they may be more or less stationary though the cinder-like texture becomes more pronounced.

A subsidiary feature very well marked in skeletal history is the progressively increasing individual variation in appearance and progress of age change from thirty-five years onward. It is as though the rigorous control of differentiation by nature were little by little relaxed, the individual having, as it were, fulfilled the physical requirements for which he was ordained and being now a less desirable creature from nature's point of view. I do not mean to press this figure of speech: it suffices to clothe the impression which I wish to convey.

This field of investigation is virgin and affords so much opportunity for work that we must not be expected to set forth all our researches in detail for years to come. Until then determination of age will be largely the perquisite of those who have worked upon this material at Reserve alongside us and have learned by practical experience, covering a battalion of skeletons, how to interpret differences sufficiently obvious when studied by the quantitative method.

Age at Death in Roman Provinces

In 1913 Macdonell published a very important essay on the expectation of life in Rome and the Roman colonies in Spain and Africa, based upon data extracted from the Corpus inscriptionum latinarum of the Berlin Academy.[9] These Inscriptiones give the ages recorded on tombstones of the general population. It may be assumed that the records are not those of the lowest of the people though most often they refer probably to slaves and freedmen of the well-to-do classes in Rome and to a population of somewhat higher social status in the colonies. There is no conclusive evidence at present of the precise date of these records although they are all certainly within the first six centuries of the Christian era and mostly belong to the third and fourth centuries. It was Marcus Aurelius who first introduced official registration of births in Rome and the provinces. For astrological purposes also the age, especially the day and the hour, was necessary. The age of Christians is stated as a rule with greater accuracy than that of non-Christians. Many of the tombstones have the letters P. M. (plus, minus) prefixed to the age, especially when the age is given in multiples of five. This habit of stating age in multiples of five becomes more pronounced as individuals grow older and results in a jagged appearance of the curves (Fig. 2). It would be interesting to know if these provincials, especially those of Africa, were of Roman descent. As emigration of Italians is known not to have been great, and as many of the names are native in origin, it is probable that we are dealing frequently with the graves of people of local African origin. These are not Negroes but North Africans, Carthaginians and the like.

From the records summarized in the foregoing statements it is clear that the Inscriptiones give a fair idea of the mortality curves in Rome and the Roman colonies in Africa and Spain during the first three or four centuries A. D.

[9] *Loc. cit.*

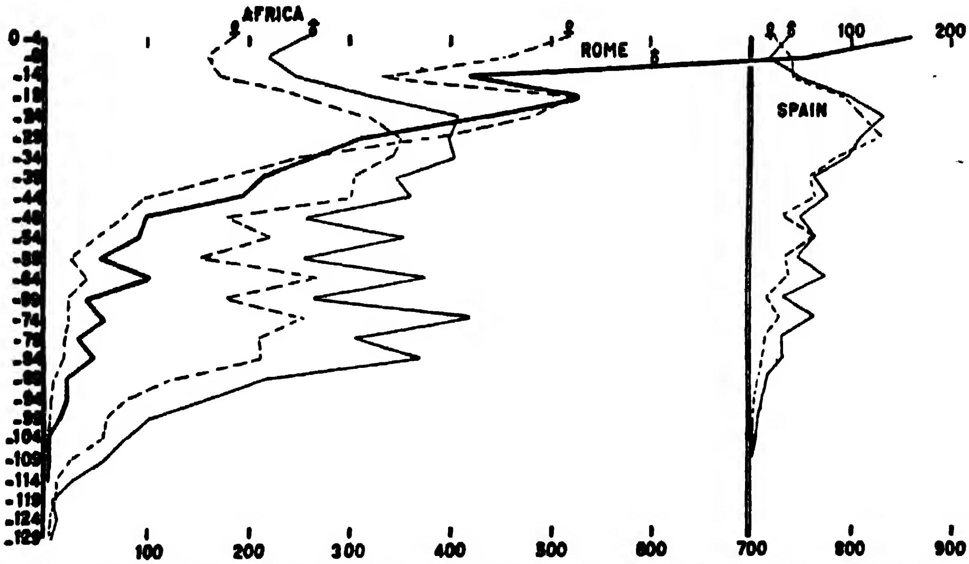


FIG. 2. GRAPHS OF MORTALITY FOR BOTH SEXES IN ROME AND THE ROMAN PROVINCES. BASED ON DATA GATHERED BY MACDONELL.[4] ORDINATES IN YEARS OF AGE: ABSCISSAE IN LUSTRA OF FIVE YEARS. NOTE THE EARLY PEAK OF MAXIMUM MORTALITY AND THE INCREASING FLUCTUATION AFTER THIRTY-FOUR YEARS.

What may be the cause of the peculiar curve for Rome itself we need not pause to inquire. The curve is plainly abnormal and hence is of no moment for our present investigation.

The mortality curves for the African and Spanish colonies, on the other hand, bear the mark of approximation to normality. In both geographical areas the peak comes in the third decade for both males and females. It is important to notice that a saw-tooth character appears in both curves only at the end of the fourth decade. Up to this date the curves are regular; thereafter a significant fluctuation takes place which, it will be found, is matched in our own curves from the dissecting room. The only satisfactory explanation of this jagged character of the curves is a lack of precision in recording the exact age. While for astrological purposes the birthday is remembered, the year of birth becomes forgotten. This is sufficiently obvious in later years of life, even as it is to-day. One can not accept without question the statements of old age as recorded on the Inscriptiones which indicate a duration of life of about one hundred years as not uncommon, especially in Africa.

The peak which appears about sixty years in Spain and about seventy years in Africa must not pass unnoticed. Though not so high as the peak of the third decade it is high enough to indicate a second mode in the mortality curve. Whereas, in the light of data still to be presented, the earlier peak may be considered that of young or middle age this one must be regarded as the peak of old age.

CURVES OF MODERN MIDDLE AGE MORTALITY

Attention should next be directed to the dissecting room curves. The population represented by the material in our anatomical laboratory can not by any stretch of the imagination be regarded as typical of the community. This sample is distinctly selected. Its

composition has been discussed in an earlier paper.[10] This is not a pure hospital population such as Pearson has studied,[11] for besides the regular hospital patients it contains relatively few victims of chronic diseases, but, on the contrary, includes many individuals who have met their death in sudden and violent manner through accident, by homicide and at their own hands. There has been no conscious selection by age. It may be assumed with some confidence that the series is a fair sample of the population of Cleveland which, through some inherent mental or moral inadequacy, is unable to make those adjustments necessary to a successful life in modern environment, "paltry victims to the spirit of mental and social restlessness that makes so many unhappy in these days."[12] In other words, they are the people to whom are denied the security of life and the comfort of living which are characteristic of our civilization.

Figure 3 gives the mortality curve of 445 white males delivered to the laboratory between 1913 and 1921. These records were collected for another research, namely, an investigation of cranial thickness: they can therefore have no bias favoring the present inquiry. Once again we see the tendency of the patient to give his age in lustra of five years, just as in the Roman mortality curves. The median of this series falls in the age of forty-five years, a rather significant fact, inasmuch as forty-two years contains the peak of death in Pearson's curve of middle age mortality (Fig. 1).

Figure 4 is the mortality curve for 250 male Negroes also delivered to the laboratory during the same period. Again appears the tendency to give the

[10] Todd, T. W., and Kuenzel, W., 1924, "The Thickness of the Scalp." *Journ. Anat.*, Vol. 58, p. 237.

[11] Pearson, K., Blakeman, J., and Lee, A., 1905, "A Study of the Biometric Constants of English Brain Weights and Their Relationships to External Measurements." *Biometrika*, Vol. 4, p. 125, also Greenwood, M., 1904, "A First Study of the Weight, Variability and Correlation of the Human Viscera. *Biometrika*, Vol. 3, pp. 64–65.

[12] Hardy, T., 1895, "Jude the Obscure." Ed. 1923. New York. p. 387.

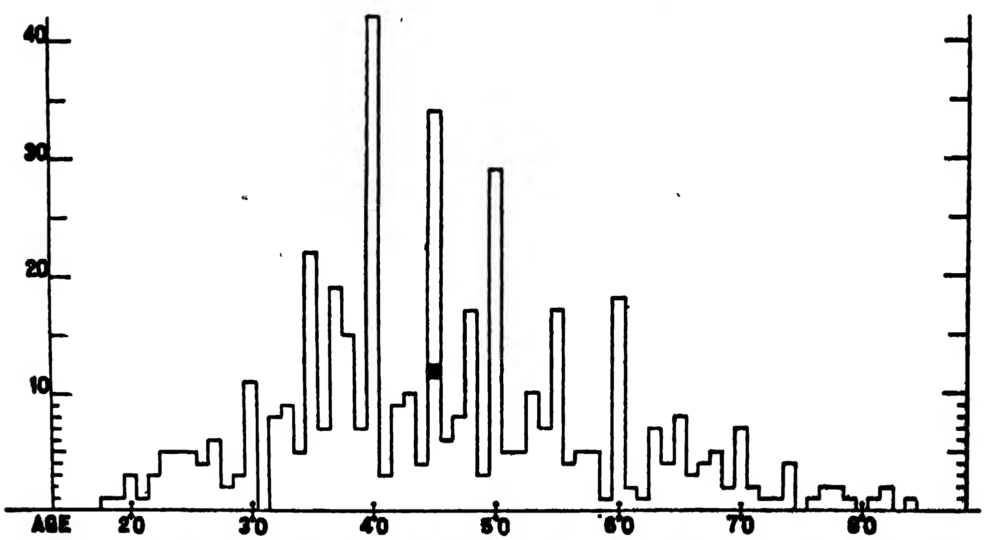


FIG. 3. MORTALITY GRAPH FOR WHITE MALES IN DISSECTING-ROOM POPULATION, CLEVELAND. ORDINATES, AGE IN YEARS: ABSCISSAE, NUMBER OF INDIVIDUALS. NOTE TENDENCY TO GIVE AGE IN LUSTRA OF FIVE YEARS. MEDIAN IN BLACK SQUARE.

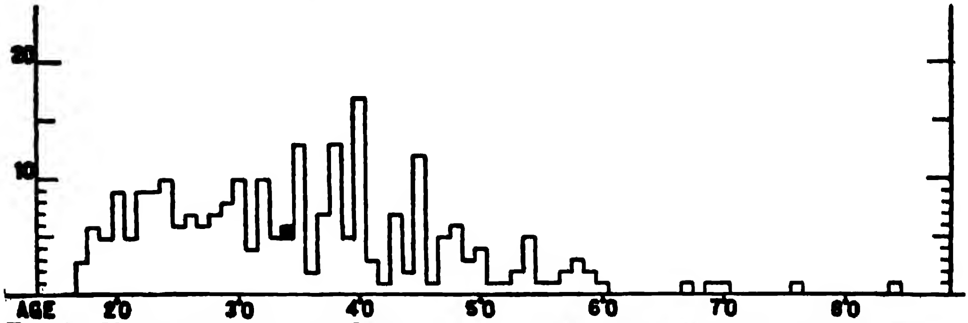


FIG. 4. MORTALITY GRAPH FOR NEGRO MALES IN DISSECTING-ROOM POPULATION, CLEVELAND. ORDINATES, AGE IN YEARS: ABSCISSAE, NUMBER OF INDIVIDUALS. NOTE TENDENCY TO GIVE AGE IN LUSTRA OF FIVE YEARS. MEDIAN IN BLACK SQUARE.

age in lustra of five years, though this is not so marked as among the whites, because the habit seems to develop after the age of thirty. The median of this series falls in the age of thirty-three years. I am not sure that the difference in position of the median from that of the white males is a true difference. It may well be that we have here a confusion due to the overlapping of a curve of adolescent death: for there are relatively many more Negro deaths in the third decade. The significant fact is that death in this population occurs relatively early in life. It is not a population of state-supported paupers, like the dissecting room material in England. There is here no indication whatever of Pearson's curve of old age death.

MORTALITY AMONG PRIMITIVE PEOPLES

I. *West African Tribes*

During 1925 I had the good fortune, through the courtesy of Sir Arthur Keith, to be able to study the series of skulls of West African tribes housed in the Museum of the Royal College of Surgeons in London. In this series are 189 skulls, excluding those of children. With some of them are definite records of sex and even of approximate age, but for the majority sex and age must be diagnosed by anatomical means. In several recent articles I have dealt with the age indication of suture closure.[18] The general plan of suture union seems to be a real progress of union from about twenty-two to thirty years, at which time there is a definite inhibition of progress. This is a slowing up of union, not a prohibition of further closure. As a result individual variation is so great that suture closure, especially on the exterior of the skull, can not be used as a very reliable age indicator: its evidence gives an approximate date only. Texture of the skull, on the contrary, is a more certain guide. So far it has proved impossible to set forth our experiences with skeletal texture in an intelligible manner; age estimation by this means is a matter of experience which can be demonstrated upon actual material. We usually make the estimate in lustra of five years.

Of the West African skulls in the College of Surgeons collection there are 108 male, 79 female and two of uncertain sex, it being understood that these figures are the outcome of my own estimation of sex, where that is missing from the record, and not necessarily the sex given arbitrarily in the catalogue. I have discarded the catalogue statements, as they record the appreciation of laymen or of

[18] Todd, T. W., and Lyon, D. W., 1924–25, "Cranial Suture Closure," Parts I, II, III, IV. *Journ. Phys. Anthropol.*, Vol. 7, pp. 325–384; Vol. 8, pp. 23–45, 47–71, 149–168.

medically trained observers with but little experience of the features of the Negro skull.

The result of my notes upon age of this West African population is recorded in Figure 5. The median specimen is indicated by the circle and falls in the lustrum ending at thirty years. This is rather striking when we recall that the median of the W. R. U. modern American Negro laboratory population falls in age thirty-three years. The peak of mortality falls in age twenty-five to thirty years. This again is striking in view of the fact that the peak of Roman Africa also falls in the third decade. Of course Roman Africa and West Africa are widely different areas and the inhabitants represent quite diverse populations. The really significant fact is that an earlier peak occurs among the West Africans in the third decade and another in the sixth.

Now it is impossible to exclude artificial selection among these skulls. Many skulls were chosen from cemetery material by the donors, and it is natural to suppose that these collectors would choose the skulls which seemed to them most "perfect." By this we must infer completeness of skull (not necessarily presence of the mandible), a good and relatively unworn dentition, and plain visibility of suture lines. It should, however, be remembered that native African skulls are apt to retain a good dentition throughout the majority of adult life, and also that suture lines on the exterior of the cranium do not obliterate early or completely as a rule. The bias would appear to be in favor of the young adult skull, and one may inquire if the peak during the third decade is not really a spurious result of artificial selection. It is my experience, however, that the skull which remains intact longest after burial is not that of the young adult, nor of the senile individual but that of the middle aged person, between forty and fifty years. Cemetery material is likely to yield far more of these skulls intact than those of younger or older people. Hence the collector's desire to obtain young skulls would be to a large extent neutralized by the material among which he would have to choose.

Turning now to another doubt which rises regarding such material, namely, the question of its origin, was it, for example, material from the bodies of warriors slain in battle? The answer to this is given in Table I shown below. It is not usual for an African tribe to give permission for the exhumation of its own people. The tribe will more readily accord permission for the rifling of a ceme-

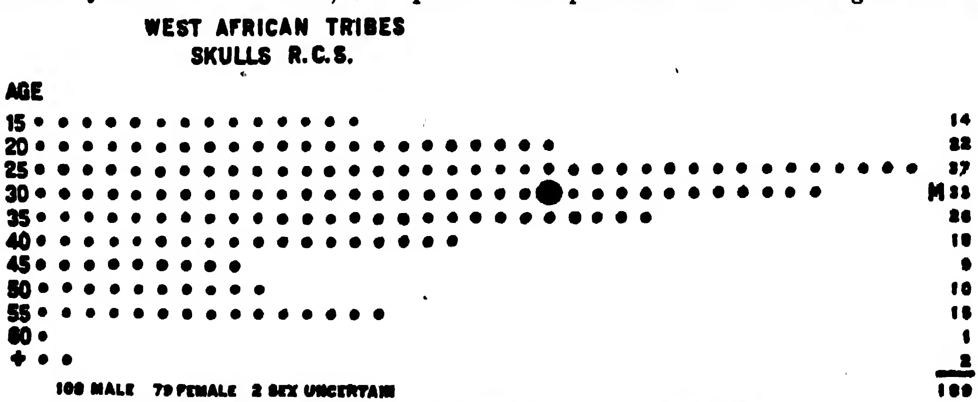


FIG. 5. MORTALITY GRAPH BASED UPON AGE ESTIMATES ON SKULLS OF WEST AFRICAN NEGROES. ORDINATES, NUMBER OF INDIVIDUALS: ABSCISSAE, AGE IN LUSTRA OF FIVE YEARS. MEDIAN ENCIRCLED. MEAN AGE AT DEATH INDICATED BY LETTER M.

TABLE I

WEST AFRICAN KNOWN TRIBES
Royal College of Surgeons (including Barnard Davis collection)

Texture years	Sex unknown	Male	Female
15		2	12
20		14	8
25	2	21	16
30		21	12
35		16	10
40		9	9
45		6	3
50		6	4
55		10	5
60		1	0
60 +		2	0
Totals	2	108	79

tery of outlanders who have died on their territory during a trading journey. Somewhere in his writings Sir Harry Johnston records the observation that Negroes are only locally immune to the peculiar African diseases which are insect borne. If the native be transferred as little as sixty miles from his home he is susceptible just as are other foreigners to the locality. The relatively large number of females indicates that the sample is that of a general population, and the earlier peak of mortality in the third decade coincides in the two sexes. The later peak is not apparent in the females, probably because of the small number of individuals represented.

Despite its shortcomings this sample of native African humanity, being all we have as yet to guide us to a record of West African mortality, may be utilized with some confidence in a comparison like that upon which we are now engaged.

II. *Tasmanians*

Partly owing to the habit of cremation, but largely for other reasons, the recently extinct Tasmanians have left but few records of their physical features. The largest collection to-day is that in the College of Surgeons, which contains thirty-six skulls with a few skeletons. Of the skulls thirty-two are sufficiently complete to be used in this study. The collection includes a number originally belonging to Barnard Davis in whose Thesaurus craniorum[14] and in the official catalogue of the museum are descriptions of the finding and recovery of these skulls which vie with tales of adventure in thrilling incidents and suggestions. "I will not speak of our labours and dangers in the adventure: it was the painful occasion of the loss of two of our three boats with their crews of nine men," writes Dr. Archibald Sibbald, R.N., in 1854, presenting one female cranium to the museum,[15] a child of sixteen years, according to my observations. The worst of all records is that of cranium 1417 from the Barnard Davis collection in which it has the number 1121.

Dr. Joseph Milligan, "Protector of the Aborigines," gravely sets forth the details of the murder of this native, a man of thirty-five years according to the skull texture, by a nightmare ridden hut keeper in a record[16] equalled only by Du Chaillu's terrified description of the "ferocity" of the gorilla.[17]

Figure 6 gives the result of my study of age on this small population. Again the peak of mortality is early, occurring at fifteen years. The majority of deaths took place about or before twenty-five years, though there is suggestion of a second peak in the sixth decade. The sample is much too small for emphasis, but the curve is significant, to my mind, in that its peaks follow the general rule

[14] Davis, J. B., 1867, "Thesaurus craniorum." London.

[15] Flower, W. H., 1879, "Catalogue of the Specimens illustrating the Osteology and Dentition of Vertebrated Animals," Part I, "Man," pp. 201–202. London.

[16] Davis, J. B., *loc. cit.* pp. 270–271.

[17] Du Chaillu, P., 1861, "Explorations and Adventures in Equatorial Africa." London. pp. 350–352.

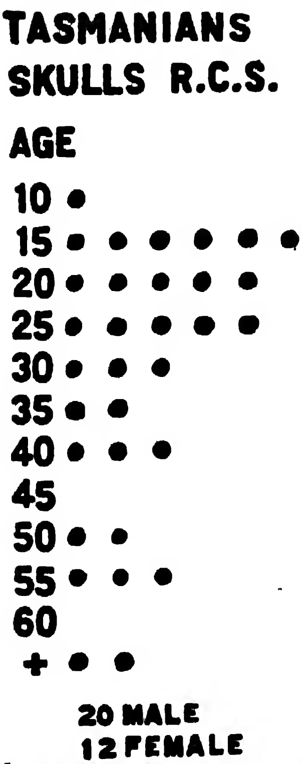


FIG. 6. MORTALITY GRAPH BASED UPON AGE ESTIMATES ON SKULLS OF TASMANIANS. ORDINATES, NUMBER OF INDIVIDUALS: ABSCISSAE, AGE IN LUSTRA OF FIVE YEARS.

observed so far in the observations set forth in this paper.

The details by sex are given in Table 2. In view of the greater resistance offered to decay by skulls of forty and more years, it is quite remarkable to find so many young crania.

MORTALITY IN ENGLISH POPULATIONS

I. Bronze Age. Furness

Through the kindness of Mr. William Atkinson, of Ulverston, I had the opportunity, in 1925, of examining the remains of sixteen individuals of the Bronze Age in a disc burial on Birkrigg in Furness. Though the remains were scanty and my time short it was sufficiently evident that the age of all sixteen persons ranges from seventeen to thirty years; there were none older than this. It is by no means my intention to suggest that Bronze Age people did not live to a greater age. I merely desire to record the experience at this one particular burial, the only site which fortune enabled me to visit.

TABLE II

TASMANIANS

Royal College of Surgeons (including Barnard Davis collection)

Texture years	Sex unknown	Male	Female
10		0	1
15		2	4
20		4	1
25		3	2
30		2	1
35		2	0
40		2	1
45		0	0
50		1	1
55		3	0
60		0	0
60 +		1	1
Totals	—	20	12

II. The Scarborough Medieval Community

"In a plot of ground half-an-acre in extent, on the seaward extremity of Scarborough Castle Hill, are three quite distinct types of ancient remains: a Bronze Age village, a Roman signal station, and no fewer than three chapels, one earlier and two later than the Norman Conquest."[18]

Mr. F. G. Simpson, who explored the area with a thoroughness and precision of detail most inspiring in its nature, was kind enough to take me over the site and expound the results of his work. At the same time Sir Arthur Keith and Miss M. L. Tildesley, in whose charge the skeletons now are, at the College of

[18] Collingwood, R. G., 1925, "The Roman Signal Station on Castle Hill, Scarborough." Printed for the Corporation of Scarborough by E. T. W. Dennis and Sons, pp. 1–8.

Surgeons, permitted me to examine the remains at my leisure. Of these one hundred and forty-three were suitable for my purpose and with Miss Tildesley and Miss George I made a record of the skeletal age of each. The bones on which we were able to make notes dated from the eleventh, twelfth and thirteenth centuries. One of the most striking features of the skeletons was the fact that tooth wear gave no indication of age. Indeed it is possible to separate the skulls into two series, one showing little wear and the other relatively considerable wear of teeth at identical ages. I am led thus to believe that we encountered, in this site, either two grades of society or a marked reduction in the coarseness of food during the two hundred years or more represented by the skeletons. The former theory has probably more to support it than the latter. Once again we estimated texture ages in lustra of five years.

Figure 7 gives the mortality record with the total numbers for each lustrum at the right-hand side. Of the young children it was impossible to make an adequate study, but our records show a peak in childhood in the second lustrum, an adolescent peak at nineteen, a middle-age peak early in the fifth decade and the suggestion of another late in the sixth decade. There is no peak of old age. Granted that senile skulls do not weather so well as those of middle age, the theory of accident will not account for the relatively small number of aged members of the community, for in this series the skeletons were preserved also in very many instances. We must conclude then that few individuals reached advanced years. The median of the series falls in age thirty-five to thirty-

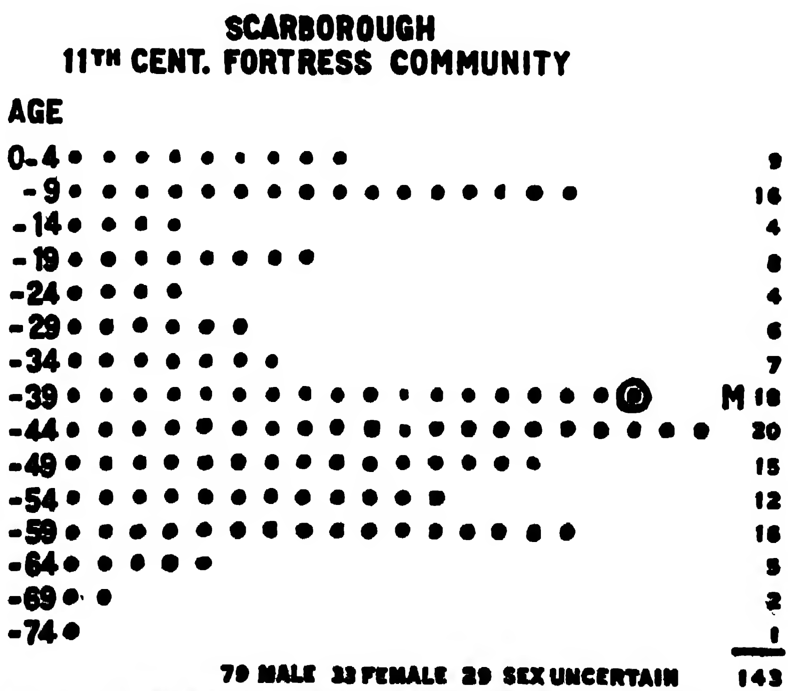


FIG. 7. MORTALITY GRAPH BASED ON AGE ESTIMATES OF SKULLS AND SKELETONS INDEPENDENTLY OF MEDIEVAL ENGLISH COMMUNITY AT SCARBOROUGH. ORDINATES, NUMBER OF INDIVIDUALS: ABSCISSAE, AGE IN LUSTRA OF FIVE YEARS. MEDIAN ENCIRCLED. MEAN INDICATED BY LETTER M.

nine years. There is a suggestion of a plateau from the fourth to the sixth decade, as most deaths occurred during this phase of life.

As a check on these anatomical observations just recorded we may turn to the pages of Montaigne. But it is to the Florio edition that we must refer in order to get the requisite flavor: the new Ives translation, literal and laborious, prejudiced by unwarranted assumptions, will only mislead in these passages. Miss Norton and Mr. Ives make the curious inference that in speaking of the age to which ordinarily a man might hope to attain, Montaigne wrote in disregard of contemporary facts. Whatever qualifications these authors otherwise show, the student of Montaigne, with the context of the Essayes before him, will have to discount their straining at the text on age.[19] "I was borne," writes Montaigne, "betweene eleven of the clocke and noone, the last of Februarie, 1533. . . . It is but a fortnight since I was thirty-nine yeares old. I want at least as much more." Then continuing, addressing himself, he writes, "Thou has already over-past the ordinarie tearmes of common life. And to prove it, remember but thy acquaintances and tell me how many more of them have died before they came to thy age, than have either attained or outgone the same: yea and of those that through renoune have ennobled their life, if thou but register them, I will lay a wager, I will find more that have died before they came to five and thirty yeares, than after."[20]

And again, in treating of age, Montaigne writes, "To die of age, is a rare, singular and extraordinarie death, and so much lesse natural than others. It is the last and extremest form of dying . . . an exemption, which through some particular favour, she [Nature] bestoweth on some one man, in the space of two or three ages!"[21]

With these significant words of Montaigne ringing in my ears and fresh from the Scarborough skeletons, by a rare piece of good fortune I encountered Mr. Harold Hulme, then of Cornell University Historical Department, at work in the British Museum upon the records of members of Parliament between 1604 and 1629 A. D. Mr. Hulme generously allows me to quote from his unpublished researches.[22] I have therefore drawn up Table III to demonstrate the age of political activity during the early Stuart period.

TABLE III

AGES OF MEMBERS OF PARLIAMENT
1604–1629
(Harold Hulme)
Of 825 known members there are records of age of 427

Age	Number
20–30	93
31–40	133
41–50	102
51–60	52
60 +	27

Under 25 years 61 members.

The peak of activity comes in the fourth decade, and there are nearly as many members under thirty years of age as between forty and fifty. The falling off after fifty is marked and the number under twenty-five years is significant.

19 Montaigne, M., The essays of. Translated by George B. Ives, introductions by Grace Norton. Cambridge, U. S. A., 1925, Vol. 1, p. 105, Vol. 2, pp. 34–5.

20 Montaigne, M., "The Essayes of Michael Lord of Montaigne done into English by John Florio with an introduction by Thomas Seccombe, the first booke," London, 1908. Vol. 1, pp. 77–78.

21 *Id.* Vol. 1, p. 450.

22 Hulme, H., "Members of Parliament 1604 to 1629," (unpublished: personal communication).

The relative youth of these members of Parliament must not be dismissed as misleading on the ground that in Stuart times the modern secret ballot was unknown. Nor must it be concluded that the positions were hereditary. The majority of the elections were genuine contests. Farmer and agricultural laborer did not exercise the franchise, but the yeoman freeholders held very important the privileges of Parliament and the principle of no taxation without representation. Trevelyan[23] (pp. 10–105) gives a very clear and impressive account of the parliamentary elections and methods of the time and I derive this synopsis from his statements. Gentry and burgesses shared between them the representation of the country, and at election time knights, squires and baronets courted the yeomen hat in hand on market days, seeking votes for their return to Parliament. Some 400 members sat for the towns, and but ninety-two for the counties. Yet since many boroughs chose country gentlemen as their representatives there was not in practice the disproportion between town and county which would appear in theory. In the official returns of each Parliament 350 out of the 400 borough members are styled baronets, knights, squires and gentlemen as against a couple of score or so aldermen, merchants and mayors. A certain number of boroughs in the Cornish villages were in the hands of the Crown or of private land owners but in the seventeenth century the proportion of these non-elective boroughs was not large. Corruption of voters by money also was not so general as it afterwards became. In many cases the English burghers preferred to look for a representative outside their own class. Hence taking into consideration all the available information we may justly conclude that the age distribution of these members as recorded by Mr. Hulme does give a substantially correct impression of the active age of manhood in the first quarter of the seventeenth century. It is probably more accurate for our purpose than the records of earlier or later parliaments up to the reform of the ballot in the earlier part of last century.

[23] Trevelyan, G. M., 1904, "England under the Stuarts," London and New York.

Thus the straws of evidence all point in the one direction. The peak of old age death, so prominent in modern mortality curves, fades into insignificance the further we recede from the present day and in the dimmer records of the distant past we find no real indication of its existence.

Mortality in Pecos, New Mexico

In recent years Dr. A. V. Kidder has been employed upon excavations on the Pecos site in New Mexico. Through the kindness of Dr. Kidder and Dr. Hooton, in whose charge the skeletons from Pecos lie in the Peabody Museum of Harvard University, I was permitted to examine this magnificent series of remains from 594 individuals, the dates of whose lives range from 800 to 1800 A. D. No other collection to which I have had access surpasses this one for completeness of skeletons, precision of data, and thoroughness of care. It is a monument to archeological efficiency. The skeletons are segregated into periods by the glazes on the pottery. Later I hope to analyze the records of the life period at the different dates indicated by these glazes. For the moment, however, our needs are fulfilled by the information given in Figure 8.

With the energetic and capable help of Mrs. Ethel Clarke Yates and Mr. George L. Williams, I assessed the age at death of these approximately six hundred skeletons and the record shows admirably the successive peaks of mor-

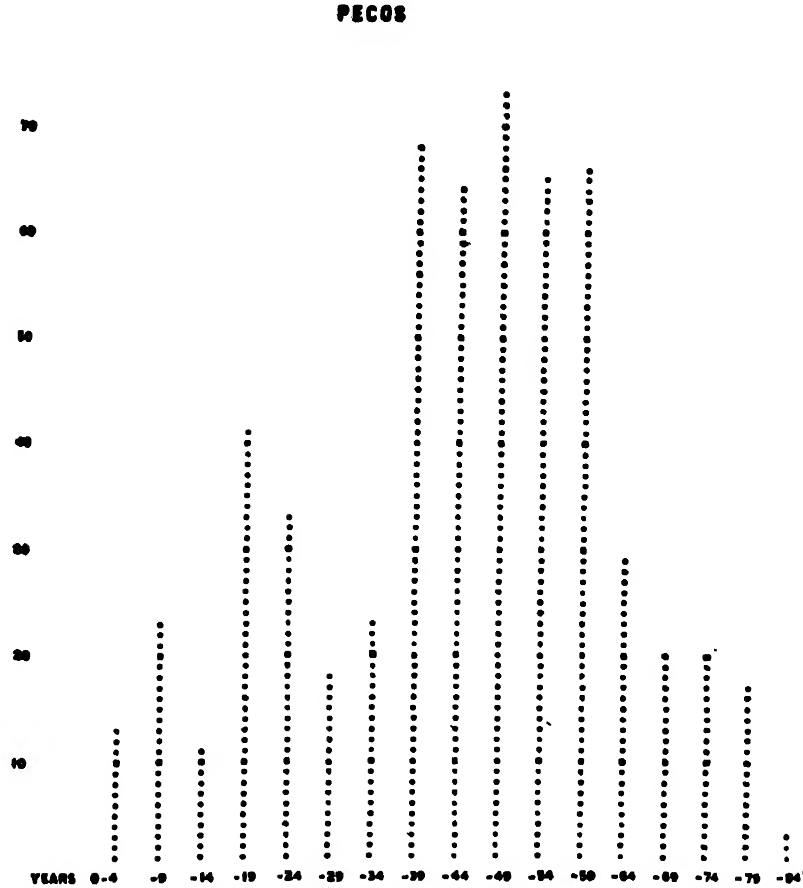


FIG. 8. MORTALITY GRAPH BASED ON AGE ESTIMATES OF SKULLS AND SKELETONS FROM THE PECOS SITE IN NEW MEXICO. ORDINATES, AGE IN LUSTRA OF FIVE YEARS: ABSCISSAE, NUMBER OF INDIVIDUALS. NOTE THE PLATEAU AROUND THE PEAK OF 45–49 YEARS.

tality. The very young children are represented by such scattered remnants that, as usual, they must be discarded. Hence our first peak falls in the second lustrum. The adolescent peak between fifteen and nineteen years is quite striking. After that there is a plateau from the later part of the fourth to the later part of the sixth decade with the median skeleton falling into age forty to forty-four years. After the sixth decade the number of deaths falls off rapidly and old age shows no peak.

Over the thousand years represented by this series there is no indication that life to old age was anything but an exception.

CONCLUSION

The inference to be drawn from these several studies seems very clear. The various peaks of mortality coincide pretty well throughout the investigation and they reproduce fairly the several peaks into which Pearson has analyzed our modern mortality curve. The commanding peak of middle age death is not accounted for by the accident that skulls of forty to fifty years weather better than others, for this peak is confirmed by the skeletons as well as the skulls.

In the times when Rome imposed her peace upon the civilized world, there is evidence of frequent survival to old age, but this peak of senility is quite lacking in the troubled times of medieval England and the little known native culture of the American continent.

In the native populations of West Africa and, so far as we have evidence, of Tasmania, the peak of mortality occurred at a relatively early age, but this has its reflection in the early peak of our Negro population of the dissecting room.

The peak of middle age death for populations other than those of Africa and Tasmania occurs in the early part of the fifth decade and this again finds parallel in our white dissecting room population.

Obviously, the modern series of the Western Reserve anatomical department give no indication of actual duration of life in the general population of the country but rather represent that stratum of society subjected to hazards in many ways comparable with the risks of the medieval and native populations which have been investigated.

The superficial observation that, among native tribes, old men are often encountered has no bearing on this problem. It is natural to put forward the patriarchs with their accumulated wisdom when strangers are in evidence or bargains are to be made. We must not let this human impulse blind our eyes to the naked record of the bones. "And the Lord commanded Moses concerning the Levites, saying . . . and from the age of fifty years they shall cease waiting upon the service and shall serve no more."[24] Perhaps our best evidence will always be, at least for those generations long since gathered into oblivion, the evidence of the skeletons which Time has not effaced. At least the possibility of reconstructing once more something so intimate in the life of these lost centuries as the record of mortality gives us a closer link with those who have passed before us along the pathway of humanity.

Trevelyan[25] concludes his delightful work with an inspiration aptly fitting the mood in which we must draw this record also to a close. "The more honestly we attempt to compute the number and quality of the things wherein the value of life consists even in our own generation, and at our own doors, the more complex and difficult does such a calculation appear. How much less, then, shall we be able to pluck out the innumerable secrets of the past, count them, weigh them, and so find the total value of some dead century. What we know is indeed an infinitely small part of what has been; but it is all that is left us now and by it we can still escape in imagination from the decree passed against each of us at his birth, that he should not issue forth from his narrow space of years, with its little circle that looks so large, of modern thoughts and sights and sounds." . . . Through these poor skeletal records, as through Trevelyan's sages and poets, heroes and martyrs of history—"through these alone can all the dead live so that the living may see them where they stand."

Summary

(1) By the examination of skeletons it is possible to estimate the age at death of ancient or primitive populations.

(2) The chief difference between these peoples and civilized populations of to-day is the apparent fact that the peak of old age death is a comparatively modern achievement resulting from greater safety and improved conditions of living.

[24] Numbers, VIII, 25.

[25] *Loc. cit.*, pp. 516–7.

(3) The difference between the peaks of mortality in primitive and ancient people on the one hand and of modern civilized humanity on the other is roughly thirty years.

(4) This difference does not indicate a prolongation of the potential duration of life which undoubtedly remains stationary through the ages.

(5) In modern populations, even in civilized communities, drawn from the lower strata of society, the old age peak characteristic of to-day is not to be found, owing to the relatively great hazards of life to which these unfortunate people are exposed when not sheltered by specific social legislation.

THE STUDENT OF NATURE[1]

By Dr. PAUL R. HEYL
BUREAU OF STANDARDS

THE long life of Sir Isaac Newton comprised many different activities. For a brief period in his early years he practiced alchemy, being engaged with a relative in the search for the philosopher's tincture. Though never in holy orders, he devoted considerable attention to theology, and was a forerunner of the modern school of "higher critics." For the last thirty years of his life he was an important and highly paid official of the British government—the master of the mint. He was a good citizen, active in the defense of the traditional rights of the universities against political encroachment. But for none of these is he remembered to-day. Hundreds of men have equalled or excelled Newton in such respects, and all have been swept by relentless time into the limbo of mediocrities.

It is a matter for the instruction, reproof and correction of the materially minded to reflect that he to whom we are met to do honor is remembered for that period of his life when he was one of a class to-day often despised and rejected of men—a college professor, and withal for some years so straitened in circumstances that because of his inability to meet his payments to the Royal Society "it was agreed to by the council" (in the quaint language of the old record) "that he be dispensed with, as several others are." It is to be added, however, that he was later reinstated and that he served the society as its president for the last twenty-five years of his life. But it was during this period of narrow means and social obscurity that Newton accomplished the work which has made his name immortal. It is as a student of nature that he is remembered, and it is as fellow students of nature that we do honor to his name.

And what is there so remarkable about the study of nature that it should confer such distinction upon its devotee? Perhaps if we were suddenly called upon to answer this question we might hesitate. It may therefore be worth our while to devote a little time to the observation of the natural history and habits of this particular human type as illustrated by the concrete case of Newton.

How does this type originate? What are the predisposing causes which lead one to take up the study of nature? This question is difficult to answer because in so many notable cases the student does not consciously "take up" the study at all. It frequently seems to be a matter of predestination. Maxwell showed his bent almost before he could talk plainly; and in Newton's case this precocity was the more evident because of the absence of scientific suggestion in either his heredity or his environment as a child. He was the son of a small farmer, and it was originally intended that he should follow his father's occupation. The school curriculum of his day was composed principally of Latin, which was so little to the young Newton's taste that he was for a time regarded as a dull boy, perhaps the more so because he spent much time in the construction of windmills and mechanical toys; but he later lived down this reputation and stood well in his classes. It is as natural for a Newton or a Max-

[1] Published by permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce.

well to turn to the study of nature as it is for a duck to swim, an artist to paint or a poet to sing.

It is told of Newton that when he was in his fifteenth year it was his mother's custom to send him to town on market days in the company of a faithful family servant. Such a trip to a normal country boy usually means a day of excitement and pleasure; but how did the young Newton spend his time in town? He allowed the servant to attend to the errands which occasioned the trip (as indeed most boys would have done) but he spent the precious hours of the day, oblivious to the attractions of the village, among the books of the local apothecary.

The fascination of nature for the child is understandable. Every one of us is born into a wonderland, and our endless questions about what we see sometimes try the patience of the adult and often exceed his ability to answer. And the mature student of nature is characterized by the retention to a remarkable degree of certain of the mental characteristics of the child: his fresh wonder, his insatiable curiosity. Such a one never becomes blasé. To the end of his days he is keenly sensitive to the wonder of the commonplace. Even so simple a phenomenon as the falling of an apple from a tree may start within him a train of thought which may lead up to a great generalization, such as the law of universal gravitation.

The childlike side of the student of nature is well illustrated by the story told of Faraday by a visitor who happened to be present when the scientist had reached a successful conclusion to his experiments on electrodynamic rotation. The visitor tells that when Faraday saw the current-bearing wire revolving about the pole of the magnet he executed a childish dance of delight around the table and insisted that his visitor should accompany him forthwith "to Astley's and see the performing horses."

That the motives of the student of nature are in part instinctive and childlike is, I think, well understood by people in general. This is one reason for the amused tolerance or even contempt with which he is regarded in certain quarters. But when the student of nature becomes a man, though he may not altogether put away childish things, he adds to them the rational motives of the adult. For this he sometimes receives scant credit. "Will you tell me," asks some one, in a wondering or perhaps contemptuous tone, "why a man of your abilities should spend his time as you do when he might be making real money at a man's job?" The scientist frequently allows such a question to go unanswered, because he realizes that if the answer could be understood the question would probably not have been asked. Sometimes when questioned thus he will direct attention to the occasional important practical application of his researches, though he does not regard this himself as a complete explanation of his own conduct. He may hand out this answer as an *argumentum ad hominem*, but as nothing more. Equally unsatisfactory is the explanation sometimes advanced for him that the scientific man is actuated primarily by the desire for fame, for the approbation of his fellows. Both this and the practical motive have place in the psychology of the student of nature, but he knows in his own soul that if the progress of science had depended solely upon these incentives it would never have reached its present state.

It is true that there is in the mind of every scientific worker a very human enjoyment of the pleasure of the game. With each obstacle overcome, with each difficulty resolved, we feel our muscles growing, and we rejoice as a strong man to run a race. But potent as this motive

may be and omnipresent as it is, the thoughtful student must admit its essentially selfish character; and when we ponder over the nature of the phenomenon we are endeavoring to explain the conviction is borne in upon us that nothing selfish is either deep or broad enough to account for it. The most potent motive actuating the student of nature, as in fact nearly every one else, must be idealistic.

One motive of this description is illustrated by Newton's case and by other scientific workers that might be mentioned, particularly Faraday. Newton's mind was of a distinctly religious cast, as his writings show. Such a mind finds much in the aspect of nature to nourish and foster this religious feeling, and conversely finds in its own point of view the justification for its efforts; for to such a mind the unraveling of the secrets of nature is but following the thought of God, the fulfilling of the chief end of man. To such a mind no other motive appears necessary; yet the student of students of nature must recognize that this is not the whole story, even in Newton's case.

There are many scientific men to-day in whose mental make-up the religious motive (at least in the traditional sense of that term) seems to play but a minor part. In some extreme cases it appears to be altogether absent; yet such types are just as zealous and industrious in the study of nature as their more patently religious brethren. For the motives actuating such cases we have still farther to look.

Newton's greatest scientific production, that for which he is chiefly remembered to-day, is undoubtedly the Principia, the "Mathematical Principles of Natural Philosophy." And what was Newton's object in writing this work? Not primarily the greater glory of God, though its pages are not without devout reference; the motive of the book is obvious to the most casual reader: the reduction of all the phenomena of mechanics, terrestrial and celestial, to law and order and, so far as possible, to a single cause—gravitation; in other words, the explanation of nature.

So deep has been the impress made by this work upon subsequent scientific thought that it is hard for us to-day to put ourselves in the mental position of scientific students prior to its publication. Such students there were, and they were by no means lacking in acumen, but the sum of their accomplishments amounted only to a number of isolated facts and a few shrewd speculations.

Kepler had discovered by his studies of Mars that a planet moves in an ellipse with the sun in one focus, and that the radius vector drawn from the sun to the planet sweeps out equal areas in equal times. Later, he announced the law connecting the distance of a planet from the sun with its time of revolution to its orbit. But these laws as stated by Kepler were merely observed facts with no correlation and no satisfactory assigned cause. Horrocks, one of the two first observers of a transit of Venus, had in a vague way suggested that possibly the earth's gravitation might reach to the moon, but he offered no demonstration of it. The inverse square law of gravitation had, it seems, prior to the publication of the "Principia" occurred to at least three contemporaries of Newton. But Newton possessed what was lacking in these others—vision, a broad mental grasp, a good sense of perspective. He was able to visualize all moving bodies in the universe, from comets to falling apples, and to reduce them to a few laws, which in turn he showed to be corollaries of a single cause—gravitation.

How thoroughly this task was accomplished is evidenced by the change in the mental attitude of scientific men since Newton's day. The "Principia" is

taken for granted; the picture of the universe there set forth is part of our common heritage, almost innate. Newton succeeded in endowing all scientific posterity with that vision and perspective which he alone possessed in his day. By the hands of Newton we have been lifted and placed upon a peak which he himself could not reach, from which, like Moses of old, we may look over the Promised Land, though it may be reserved for those who follow us to enter.

Nearly two centuries later a similar crystallization and correlation of disjointed facts in the biological realm was brought about by Darwin with the publication of the "Origin of Species"; and the present state of physical science is again one of such bewilderment, such wealth of uncoordinated detail that the time is ripe for another such genius as Newton to make his appearance. Even Einstein does not go far enough; and Planck, with his quantum theory, has up to the present succeeded only in making us feel worse before we feel better.

To explain the universe! Is not this the characteristic and fundamental motive of all students of nature? It is true that in attempting to do this there have been advanced some explanations that were fantastic, and many that were incorrect or incomplete. To Ptolemy succeeded Copernicus, and to Copernicus, Tycho and Kepler, Newton and Einstein, and still the task is unfinished. But however diverse the explanations offered, the driving force of all these students has been the same. The universe is a riddle, a challenge to the intellect; and the human mind will not tolerate such a challenge. The gauntlet is picked up and the fight is on.

No motive is more widespread in humanity. In the presence of the great realities of nature the first impulse of man, whether savage or civilized, naïve or sophisticated, is to wonder; the second to guess at a cause.

Though the task before him is colossal, mere size or complexity has no terrors for the student of nature. He is perfectly aware that probably neither he nor his descendants to the third or fourth generation will complete the work. He has no assurance that it will ever be completed. Perhaps—who knows?—some great catastrophe, some celestial collision may extinguish all life on earth before the task is half done. And even if the end be accomplished, what good will it do? Will the men of that day be any happier? Will death be swallowed up in victory? But all such objections, when addressed to the student of nature, fall on deaf ears. He hears only the continual challenge: "Explain me!"—and the taunt is enough to spur him to the utmost. Because no motive could be more idealistic, no incentive could be more powerful. The human mind is proud and will tolerate no defiance.

It is said that at one time an astronomer discovered a new star, which he found to be approaching the earth with a great velocity. He calculated that it would strike the earth in a few months. He did not announce his discovery, fearing to witness the orgy of lawlessness and despair into which it might plunge the world. Night after night he studied this approaching doom, fascinated by it. One night he spoke aloud and addressed the star as follows:

> I know that you will soon destroy me and all life on earth; but I can calculate the day, nay, even the hour when this will happen, while you are but a blind, brute thing, and I would not change places with you!

For this proud attitude there is indeed much justification. The success of man in unravelling the phenomena of nature has been truly remarkable. As mystery after mystery shows itself to be more or less amenable to reason and consistent with the laws of thought we are encour-

aged to believe that nature as a whole may not be beyond our eventual comprehension. The student of nature is ever optimistic.

But against this optimism there is a barrier set up by certain philosophers. We must carefully distinguish, they tell us, with the tone and manner of a physician applying a cold compress to an inflammation, between explaining and merely describing. With the latter, they concede, we may go far, but ultimately explaining anything is a different matter. No amount of description is equivalent to the simplest explanation. The difference is one of kind, not of degree. We may know much about the *how* and nothing whatever about the *why*.

Herbert Spencer, more than half a century ago, laid down the dictum that the reality which underlies phenomena is utterly and forever unknowable to us. Many philosophers since his day have repeated and reiterated this doctrine. The ultimate aim of science, they tell us, is description, not explanation, and in support of this assertion they quote Newton himself ("Principia," Book III):

> Hitherto we have explained the phenomena of the heavens and of our sea by the power of Gravity, but have not yet assigned the cause of this power. . . . But hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses.

But while Newton in his formal and official utterances confined himself to the description of the *how*, his correspondence shows that privately he speculated freely on the *why*, as every scientific man should. There is extant a letter from Newton to Boyle, in which he lets his fancy free as to the why of gravity. Philosophers may smile at it, and call it but a glorified *how*, but the fact remains that Newton set no limits to his private thinking. If he chose to speculate as to the *why*, he did so, however abortive the result. As Browning says, "A man's reach should exceed his grasp."

Spencer's dictum of the Unknowable, as Norman Campbell says, is met by many scientific minds with a spirit of rebellion. It is admitted that in spite of our earnest efforts we have up to the present made no progress whatever in the explanation of the *why*, but it is not admitted that present failure demonstrates future impossibility. Nothing, in my opinion, would more effectually wet-blanket scientific progress than a general and cordial acceptance of this doctrine. Personally, were I satisfied that the mind is incapable of reaching an ultimate explanation of nature, I would not spend another day in the blind alley of descriptive science, but would abandon it forthwith, and turn to something which might hold out some promise of satisfying the soul.

But is such an attitude reasonable, or is it purely sentimental? Perhaps there may be more reason in it than a superficial examination would lead us to suppose. Our concept of the mind to-day is quite different from that which was current sixty years ago. In Spencer's day introspective psychology, or "mental philosophy," as it was then called, had, as was thought, pretty well explored the phenomena of consciousness, which were then regarded as constituting the whole territory of mind. The modern view is that our consciousness is but a secondary part of the mind, floating as it were on the surface of a great deep of unconscious cerebration, whence come all our ideas, as bubbles rise and burst at the surface of a liquid in which some ferment is at work. Who is there who has not had at least one experience of the working of this mysterious power? Perhaps we have puzzled for days over a difficult problem, only to lay it aside from pressure of other things; and lo! when we are least expecting it the long-

sought solution wells up in the mind. Newton must have had many experiences of this kind. He was once asked by what mental process he arrived at his discoveries. His answer was that they were usually the result of "intending his mind" continually on the subject and waiting for it to unfold. And when the solution finally reveals itself the student of nature feels as though he were on the crest of some mighty wave, borne along without conscious exertion, he hardly knows whither. So great are the unexplored possibilities of the mind as we recognize it to-day that it is no longer safe to set metes and bounds for it.

We stand in a dark room, developing a photographic plate. For some seconds nothing appears; then high lights begin to come up here and there, showing as dark patches with no apparent logical connection between them. As the development progresses correlations begin to appear among these patches, and eventually the plate shows one pattern of law and order over its entire surface.

But the most wonderful part is yet to come, for the completed picture presents to the eye an appearance of perspective, of solidity. Your *a priori* philosopher might have argued that this would be an impossibility—that the picture contains but two dimensions and can not possibly present the impression of three; but he is reckoning without his host. He is not including the mind which reads this element into the flat picture.

In our study of nature we have hardly begun the development of the plate. Patches of correlated phenomena appear here and there, but the gaps between them are yet to be bridged over. And with complete development we shall have but the *how*, a logical description of the phenomena of nature and their interrelations. And then—who knows?—perhaps this wonderful mind-power may read into the finished but flat picture the transcendental element of the *why*—the ultimate explanation of nature. Obviously this can not be looked for until the development of the *how* is far advanced, perhaps fully completed; but what matter? The student of nature, as we have seen, is not actuated by selfish motives, but by something far more powerful, of an idealistic character. What though we shall never live to see the final victory? Like Simeon in the temple we may say: "Lord, now lettest thou thy servant depart in peace . . . for mine eyes have seen thy salvation."

Yet even with this great goal in mind, and a realizing sense of the colossal magnitude of the task, the student of nature is sometimes discouraged because progress seems so slow. A lifetime of patient effort yields often but a pitiable handful of results. Newton himself was not free from this feeling. He once compared himself to a child gathering pebbles on the shore of an infinite ocean.

But a man is not always the best judge of his own achievements. Time is required to bring a true sense of value and perspective, and after two centuries I think we may safely say that in this respect Newton much underestimated his own case. He did far more than collect isolated facts; he correlated these facts and bequeathed to his successors a permanent economy of thought. He smoothed the road as far as he went that others might run where he slowly crept. He said of himself: "If I saw farther, 'twas because I stood on giant shoulders." Modesty perhaps forbade his stating the corollary which his keen mind could not help but see: that corollary the fulfillment of which has brought us together two centuries later to do honor to his memory.

We often build better than we know. There is a delightful story to this effect in the ancient myths of our Nordic race, which for its human interest and its philosophy is worthy of being placed beside that other story which has come

down to us from the ancient myths of our Semitic brothers and which tells of the first pair in a garden. And because I feel sure that the first tale is not as familiar to you as the second I am going to give myself the pleasure of telling you the story of "Thor's Journey to Jötunheim."

In the ancient city of Upsala, in the olden time, there was a temple to Odin, the chief of the gods. The king of the giants, Utgardeloki, whose race was at eternal warfare with the gods, hated Odin and, wishing to insult him, destroyed the temple and extinguished its altar fires.

When Odin heard the news he summoned a council of the gods to meet in Asgard, the home of the gods, and to this council there came among the others, Thor, one of the twelve sons of Odin.

Thor was the god of thunder. His home was not in Asgard but in Thrudvang, the storm-cloud. When he knit his brows the lightning flashed from his eyes; when he spoke it was as the roll of thunder in the heavens. In his hand he carried his magic hammer, Mjölnir, the crusher; about his waist he wore a belt of the kind possessed only by the gods, which when tightly drawn conferred strength upon the wearer.

At the council of the gods Thor's voice was raised for immediate warfare against the giants, but in this he was not supported by others, and the council broke up without anything definite having been decided upon. Thor, angered by the indecision of the council, decided to take matters into his own hands and to go to Jötunheim, the land of the giants, seek out the giant king, Utgardeloki, and punish him for the insult to his father Odin. He made no public announcement of his purpose, but left Asgard secretly. Over the rainbow bridge he went, from Asgard, the home of the gods, to Midgard, the abode of men, where he wandered for several days seeking the road to Utgard, the abode of giants. Finally, one day as evening came on he found himself lost in a forest. However, he happened to spy a curiously shaped house, without windows and with but one door which took up the whole of one side of the house. The house being empty, he spent the night in its shelter.

The next morning Thor felt the ground shake as from the tread of some great creature, and suddenly through the morning mists he saw loom up the figure of a huge giant. Thor grasped his hammer, but on second thought laid it down again, thinking that the giant might direct him to Jötunheim. The giant, not noticing Thor for the moment, said "Ah, here is my mitten!" and stooping he picked up the house in which Thor had spent the night. As he did so he noticed Thor and called him by name, saying, "I know you, Thor, by your belt and by the hammer which you carry; but what are you doing here?"

Thor replied that he was seeking the road to Jötunheim, as he had a mind to pay a visit to the giant king, Utgardeloki.

"In that case," said the giant, "we are well met. I serve Utgardeloki in giant-land and I am now returning thither. If it pleases you, we may journey together. My name is Skrymir."

Thor was glad to agree to this, and the giant continued:

"Since we are to travel together, we may as well put all our provisions in this wallet of mine, and since I am the bigger and the stronger of the two, you will permit me to carry the load."

The giant then threw the wallet over his shoulder and the two started on their journey. The giant at first attempted to dissuade Thor from his purpose, saying:

"You think I am big, but you will find others in Jötunheim bigger than I.

I know of the ancient enmity between your race and mine, and I fear trouble if you carry out your purpose of making a visit to our king. A very small happening may cause the old feeling to flare up. No good can come of your visit, and I hope you will abandon your purpose."

But Thor was not to be dissuaded, and the giant soon gave over his attempt.

They journeyed all that day without getting out of the forest, and when night fell the giant, declaring that he was too tired to eat and wanted only to sleep, threw the wallet to Thor, saying that he had better get his supper and a good night's rest, as there was a hard journey before them on the morrow. So saying, he stretched himself on the ground under a tree, and was soon fast asleep, snoring loudly.

Thor thought the giant's advice good, and attempted to open the wallet, but to his surprise found that he could not loosen the strings. He drew in his belt and attempted to break them, but failed in this also. Then anger filled his heart, and taking his hammer in his hand he went to where the giant lay sleeping and launched the hammer full in Skrymir's face.

The giant stirred, half awoke, passed his hand over his face, and fell asleep again. Thor, chagrined by his failure, withdrew; but he could not sleep. Hunger kept his anger alive, and toward midnight he drew in his belt, and going again to the giant threw the hammer with such force that the head penetrated the giant's skull.

Skrymir stirred, opened his eyes, passed his hand over his head, and said: "Did a leaf fall from the tree? Ah, Thor, you are up late! You should get some rest before our long journey tomorrow." And he fell asleep again.

Thor, more chagrined than before, again withdrew; but he could not sleep, and when the first flush of dawn was in the sky he went again to the giant, drew in his belt to the last hole, and threw the hammer with such force that it sank, head, handle and all, into the giant's brain.

The giant woke, sat up, passed his hand across his forehead and said:

"I am sure an acorn must have fallen on me to wake me up like this! But it is no matter; it is day, and we will make an early start. Come, let us go!" And he started off at a great pace.

Thor, angered and disgusted, followed him. In a few hours they reached the end of the forest, and the giant said to Thor:

"You are now in giant-land. The road to Utgard Castle lies that way; my path lies in the opposite direction, across those mountains. But once again let me persuade you not to make this journey you have in mind. Nothing but harm can come of it."

But Thor shook his head, and started off along the road indicated by the giant, while the latter, taking great strides in the opposite direction, was soon lost to sight.

Thor found it a three days' journey to Castle Utgard. The castle stood in the midst of a great plain, surrounded by ice and snow. The castle was so high that Thor had to bend his head all the way back to see its top. Its great gates were guarded by two giants, bearing sword, spear and shield. The doors not being opened promptly enough to suit Thor, he threw his hammer against them. The lock shattered, and the doors swung inward.

Thor entered a great gloomy hall, with rows of giants ranged around its walls. At the farther end of the hall sat the giant king, Utgardeloki, on a high throne. Thor advanced toward him.

The giant king recognized Thor, and spoke first, saying:

"I know you, Thor, by your hammer and by the belt you wear. It is long since one of your race has paid us the

honor of a visit. We are appreciative of the honor you show us by coming here, and we will do our best to entertain you. We will show you feats of strength, and we hope that you will give us some evidence of that prowess with which rumor credits you."

Thor was not averse to this, but said that he was thirsty after his long journey.

"Ah," said the giant king. "Are you a good performer at the mead horn?"

"Yes," said Thor, proudly. "I have never seen a horn of mead so deep that I could not empty it at a single draught."

The giant spoke to his attendants, who presently brought into the hall a drinking horn so long that its little end remained outside the door. Thor looked at its size with some misgivings, but being very thirsty, he put his lips to it and took a deep draught. But when he had finished he found to his disgust that the level of the liquid was not appreciably altered.

The giants looked amused, and Thor, somewhat nettled, took a deep breath and applying his lips again to the drinking horn drank until the veins stood out on his forehead; but when he had finished he found that the liquid had been lowered just enough so that the horn might be carried without spilling.

Utgardeloki laughed, and the other giants echoed his merriment. Then the giant king said:

"Now that you have quenched your thirst, we have a game here for children. It is to lift my cat from the floor. I would not have mentioned it had I not found you so unexpectedly weak."

There came into the hall a strange looking cat, with scales instead of fur, and with eyes that shone fire. Thor placed one hand under the animal and attempted to lift it, but the cat only arched its back more and more, until when Thor had reached as high as he could he had succeeded in lifting but one foot from the floor. Disgusted and angry with himself, he gave over the attempt.

The giant king laughed long and loudly, and the other giants joined in his laughter. Fierce anger seized Thor's heart, and he clenched his fists until the knuckles grew white, and, shaking his hammer at Utgardeloki, dared him to single combat. But the giant king said:

"All that has been has been in sport. I see no reason for anger. Still, if you insist, I will have my old nurse, Elle, wrestle a fall with you."

A toothless old woman came into the hall and springing at Thor seized him around the waist. The god struggled mightily, and withstood her long, but eventually he was forced down on one knee. At this Utgardeloki stopped the sports, saying that it was now time for the feast. But Thor was too chagrined and disgusted to eat or drink much, and all thoughts of warfare had gone from his mind.

In the morning the giant king accompanied Thor outside of the castle to show him the road back to Asgard, and when the gates were shut after them he said:

"Now that you are out of my domain, and shall never enter it again, if I can help it, I will open your eyes. All that you have seen has been enchantment, as it were a strange dream. I am Skrymir, who met you in the forest. When I learned your errand my heart sank within me, for I knew of your prowess and of the enmity between your race and mine; and I endeavored to dissuade you from carrying out your purpose of coming hither. Failing in this, I had recourse to enchantment. By magic I tied the strings of the wallet; when you struck at me with your hammer I placed a mountain between us. Three deep glens have been made in it by the might of your arm. The drinking horn had its

little end in the ocean. On your way home, when you come to that arm of the sea across which you were forced to swim on your way hither, you will find it so lowered that you can wade across it knee deep. My cat was no cat, but the great world-serpent that lies coiled round the earth, holding the world together. When you put forth all your strength to lift him and, as you thought, failed, we saw that the serpent had great difficulty in holding on to his tail, and we feared lest he should be forced to let go. When you, as you thought, lifted but one foot from the floor, we felt the foundations of the universe tremble. Elle was old age, before whom all, even the gods, must bow. But come not again, Thor, for I fear you; and I have other enchantments that you know naught of, and long will I be able to withstand you.''

At these words anger filled Thor's heart, and he threw his hammer at the speaker; but Utgardeloki and his castle had vanished, and there was naught to be seen but an empty plain.[2]

Waking time! Waking time! Lo, a man is born!
Born in Nature's wonderland, in life's fresh morn.
Nature's myriad wonders, beckoning, seem to say:
''Come, live with us and learn of us, in life's long day.''

Working time! Working time! Life's high noon!
Waste no precious moment now, for night comes soon!
Much to learn, much to do, all that man can ask.
Summon every energy to life's great task.

Resting time—sleeping time! Lay the task away;
Thou hast earned a peaceful close of life's long day.
All thou hast accomplished, little may it seem;
May'st thou see it clearly after life's strange dream!

[2] The story of Thor and the giants is found in several places. The source to which the writer is chiefly indebted is the issue of *St. Nicholas* for October, 1880.

SCIENCE IN JAPAN

By Dr. HERBERT E. GREGORY
BISHOP MUSEUM, HONOLULU

THE Science Congress held at Tokyo from October 30 to November 11, 1926, under the auspices of the National Research Council, gave to "overseas" delegates a favorable opportunity for the study of the scope, organization and personnel of Japanese science. Most delegates were pleasantly surprised at the nation-wide enthusiasm for scientific investigation and especially at the remarkable progress made during recent years. As recorded in "Scientific Japan Past and Present," the entire history of organized scientific research in Japan covers little more than a half century—a striking contrast to history of scientific study in other Pacific countries. In the United States before 1875 more than two hundred learned societies, national and state surveys and laboratories had begun publication of transactions. Several American societies have celebrated their hundredth anniversary and two their hundred and fiftieth anniversary. In Mexico the National Museum was founded in 1825 and the Geographical Society in 1833. The learned societies in Colombia, Peru, Bolivia and Chile are even older. In New Zealand eight learned societies were holding meetings before 1870—including the Dominion Museum (1863) and New Zealand Institute (1867). In Australia the Royal Society was established in 1821, the Australian Museum in 1836, and before 1860 the Commonwealth had a rather full complement of universities, museums, surveys, observatories, botanical gardens and scientific societies. In Java scientific societies were holding meetings before the close of the eighteenth century, and systematic investigations of the Pacific Ocean took a prominent place in the programs of Russian scientific societies during the early part of the nineteenth century.

For Japan, the history of organized scientific research begins in 1871, in which year the Hydrographic Bureau was organized. This was followed in 1874 by the establishment of the Imperial Hygienic Laboratory at Tokyo and in 1875 by the Imperial Hygienic Laboratory at Osaka and the Central Meteorological Observatory. These four institutions constituted the governmental scientific equipment in 1875. Up to this time there are no national, prefectural or municipal scientific societies and no private scientific institutions of record. During the fifteen-year period—from 1875 to 1890—three government bureaus—land surveys, forestry experiment station and geological survey—were established, and sixteen scientific societies came into being: four medical, three engineering, one each for zoology, chemistry, mathematics, geography, meteorology, botany, anthropology, textile research, architecture and agriculture. For the decade from 1890 to 1900, six government bureaus (national and prefectural) and eleven scientific societies were formed; from 1900 to 1910, fifteen government bureaus and seventeen societies; since 1920, sixteen government bureaus, twenty-six societies. Thus, of the eighty official scientific bureaus supported by the Imperial Government, prefectures and cities, fifty-four (about 67 per cent.) have been established during the past sixteen years. Of the ninety-three unofficial learned societies and institutions more than half have held

their first meetings since 1910 and more than one fourth during the past six years.

That this remarkable growth of institutions and professional societies represents a genuine increase in numbers of scientific workers and in specialization of interests is shown by the membership lists and the volume of publications. The enrollment in the more prominent professional societies in round numbers is: physics (three societies), 2,700; chemistry (three societies), 6,000; geography (three societies), 1,000; geology, 553; botany (two societies), 700; zoology (five societies), 1,200; forestry (two societies), 3,300; meteorology, 374; engineering (eleven societies), 18,000; medicine (thirty-five societies), 50,000.

A superficial comparison of lists of similar societies in other countries, taking into consideration population and stage of development of national resources, shows that in geography, geology, meteorology, ceramic chemistry, forestry, fisheries and systemic botany, the number of professionals is greater in Japan than that of most countries. In physics, chemistry and astronomy the numbers correspond to those of France, Austria and Italy, and stand below those for England, Germany and the United States. For botany other than systemic, the figures are approximately those of Holland, Scandinavia and Australia, and below those of the United States, England, Germany, Austria and France. For zoology the comparison is even less favorable and for anthropology the figures are about those for Belgium or New Zealand. There is no easily available method of comparison of numbers of research scientists in the membership of medical and engineering societies. The numbers in Japan compare favorably with those of most countries, except Germany and the United States, but doubtless in Japan, as certainly in the United States, most members of these professions are practitioners whose contributions to knowledge are incidental.

The history of Japanese higher education parallels that of scientific organizations. Systematic training of young men for professional and technical careers has been organized mainly during the past half century. This late development is surprisingly unlike that of other countries immediately bordering the Pacific. The Universities of Mexico, Lima and Cuzco were founded in the sixteenth century, San Tomas (Philippines) in 1611, and Santiago (Chile) in 1743. The charter of the University of Sydney is dated 1850, Melbourne 1853, New Zealand 1870. In the United States before 1875, 354 colleges and universities were teaching some kind of science and many of them were recognized centers of research. In Japan, previous to 1875, Keio, with its small medical school, and Dashisha University, without scientific departments, both established chiefly as missionary enterprises, were the only institutions listed as of collegiate grade.

In 1877 the Imperial University of Tokyo was founded for the training of men who desired to prepare themselves for professional and technical service. Its primary purpose was to bring together, enlarge and furnish more favorable opportunities for the scattered groups of writers, experimenters and observers who had been encouraged by the Tokugawa Shogunate to pursue scholarly careers. The university was given its present form—part American, part European, part Japanese—in 1886. The place the university was intended to take in the educational system is shown by the original list of departments: law, medicine, engineering, literature, science. Agriculture was included in 1890, economics not until 1919. At the present time the largest professional faculty is engineering, followed in turn by agriculture, science, literature, medicine, law and economics. The students number

about 5,000. The university maintains nine serial publications and seven research institutes outside the university campus.

Of the other Imperial universities Kyoto was founded in 1897, Tahoku in 1907 and Kyushu in 1910. Hokkaido, organized as an agricultural college in 1876 under the guidance of a group of men, was created a university in 1918. Fourteen medical and technical colleges apart from the universities were established between 1919 and 1926.

As bearing on the effect of Japanese university education on the development of science, it is worthy of note that the average age of students entering the science courses is 22.2, in the agriculture courses 23.2. Another feature of interest is that about 30 per cent. of the graduates are in teaching and scientific pursuits and but 20 per cent. in all lines of business, finance and commerce.

The history of civilization shows that science is a slow-growing plant in any soil and it is difficult to think its growth in Japan has been witnessed by men now living. Japanese scientific research and education give an impression of age. It seems highly improbable that the rapid recent increase in numbers of institutions, societies and workers represents an entirely new interest in the possession and utilization of scientific knowledge and a study of records and publications reveals a vista of scientific activity extending far into the poorly recorded past. Some branches of scientific knowledge were widespread and familiar to all classes long before contact with the outside world brought new methods and new ideas; other branches were part of the knowledge of scholarly men only; still others seem to have been outside the experience of the Japanese people.

Botany in Japan has enlisted the interest of many able minds since the eighth century. Up to the seventeenth century attention was given almost wholly to the search for, testing and methods of use of plants for medicine and for food. From the seventeenth century to the Restoration (1868) an amazing amount of descriptive work was done—the differences and relationships of plants as based on structure, type of flower, kind of fruit and habits of growth were worked out.

Between the years 285, when the first Korean professional student of medicinal plants was united to the Imperial Japanese Court, and 900, the knowledge of plants possessed by the Chinese seems to have been fairly well absorbed. In 929 this information was embodied in a twenty-volume text-book, prepared by Shitago. In 1156 three books—drug plants, perfumery plants and cereals—were written by Seiken. In the middle of the sixteenth century some knowledge of foreign medicinal plants was obtained from Portuguese and Spanish visitors and then the door was closed and the Japanese continued without outside help to gain a knowledge of their flora. In 1696 Jyaksui published a treatise descriptive of 189 food plants and started on the remarkable one thousand-volume encyclopedia of natural products of Japan. After writing 362 volumes the author died, but his pupils continued the work and in 1735 the last of the remaining 638 volumes were issued. Before his death in 1714 Kaibara Ekiken had written a treatise on the natural history of Japan, in which 358 plants are described as indigenous and twenty-nine as imported. Ranzan's work on mountain flora of Japan—herbs, two volumes; trees, four volumes—was written in 1765 (translated into French 1873). Ino Jyaksui published monographs on orchids, fungi, bamboos and cherries. Rausui, who died in 1776, published an eighteen-volume work on the botany of Loo Choo Islands. Between 1720 and 1752 a natural history survey under the direction of four distinguished botanists

was conducted by the government and local centers of study were established by imperial decree. In 1782 a natural products bureau was established at Kagoshima. Among many works published during the twenty years following is an illustrated agricultural botany in twenty volumes. Similar bureaus were established at other places. From the one at Mito came the San Kai Sho Hin (products of mountains and seas) in one hundred volumes. As an aid in exchanging information the workers at these bureaus held annual exhibitions, beginning in 1757 and continuing without interruption until 1827. In a modified form these exhibits continue to the present day. The Tokugawa Shogunate, which did little for learning in general, liberally supported botanical studies, and the present Marquis Tokugawa, himself a student of botany, established and endowed in 1898 the Tokugawa Institute for fundamental research in plant science. Though expressed in different terms, the Japanese long ago recorded relations in the plant kingdom which modern scientists express by the terms Order, Family, Genus, Species. So that when the Dutch botanist Thunberg visited Japan in 1776 and called attention to the effective simplicity of the Linnean system of nomenclature, all the Japanese students of plants had to do was to change their cumbersome descriptive phrases into the shorter and more precise Latin terms. At the time when modern American and European methods of botanical research were eagerly adopted by the Japanese, the systematic botany of Japan was probably as well known as that of any other region. With this much already accomplished, the ground was prepared for investigation in cytology, pathology, micro-anatomy, physiology and genetics of plants. The background of widespread knowledge and interest in plants, added to the voluminous descriptive records, doubtless accounts in large part for the present high rank of botany in Japan.

Horticulture

For more than a thousand years the Japanese have been not only students of plants but also lovers of plants. Their remarkable achievements in floriculture, horticulture and forestry are too well known to justify extended comment.

In 1681 Moto Katsu described the culture methods of 117 herbaceous flowering plants and in 1795 printed a twenty-volume work on camellias, azaleas and chrysanthemums which remains a standard treatise. In 1698 to 1699 Kaibara described culture methods for 190 species of flowering plants and illustrated 110 species of flowers. Other important works appeared in 1713, 1715, 1717, 1735. A five-volume work on rhododendron appeared in 1733. No less than fifty descriptive illustrated books on the morning-glory and thirty on Ardesia appeared between 1795 and 1818.

Systematic study of food plants is represented by hundreds of volumes bearing dates previous to 1800, and the study has been vigorously prosecuted down to the present time. Three purposes seem to underlie these investigations of food plants; introduction of new species, improvement in cultivation of known species and full knowledge of edible wild plants which might be used in time of crop failure and scarcity. Many of the treatises are in three to ten volumes. Tsunemasa's great work on the flora of Japan (1828) is in ninety-three volumes and Yakusa's masterpiece on useful plants (1856) treats of 1,201 species, besides six hundred species of trees still in manuscript.

Comparison of Japanese plants with those of other regions dates largely from 1776, the date of the visit of the Dutch botanist, Thunberg. By 1856 the plants of Japan had been listed on the Linnean system and equivalent European and

Asiatic species had been recognized. In 1857 a bureau for the study of non-Japanese plants was established at Yedo and in 1877 Riokichi, who had studied in America at Cornell, became professor of botany in the Tokyo Imperial University. His students include most of the Japanese botanists of the present century.

Forestry, like other branches of plant science, has been practiced in Japan unofficially for many centuries. The necessity of replanting, methods of replanting and the relation of forests to agriculture are the subjects of many books and of chapters in treatises on botany. In a publication dating from 1732, forests are given equal rank with cultivated crops and fish as natural resources to be studied and regulated.

Medicine

When the present enviable position of Japan in medical research is considered it is interesting to note that definite knowledge of the make-up and functions of the human body first came to the Japanese in 1771. Before that time theoretic medicine followed the Chinese system of "essences," "influences," "external causes" and "internal causes," supplemented by a comprehensive knowledge of healing herbs. Two important features of this early period were the teaching of Nagata about 1200 A. D. that "the secret of curing lay in helping natural agencies in their work of healing" and the introduction of crude Portuguese surgery (1568), which grew into a school called "Surgery of Southern Foreigners." As at other stages in medical practice, the physicians separated into warring schools, "Classical Medicine" and "New Medicine."

Early in 1771 Sugita happened to see an illustrated Dutch anatomical work and Mayeno saw another in a ship captain's library. Neither of these men could read Dutch, but they saw the illustration of the internal organs of the human body and were surprised to find that these organs were entirely different from those described by Chinese physicians. At first thought the discrepancy seemed natural, for externally foreigners were different: they have white skins and red hair; they sit on chairs because their knees don't bend; they use artificial heels because they have no heels of their own. But these explanations did not satisfy. The two students wanted to see for themselves the inside of a Japanese. But dissection was not only prohibited by law but was regarded with horror. Fortunately for Japanese medicine, the body of an executed criminal was made available by surreptitious means. Dissection showed that Japanese bodies and Dutch bodies were constructed alike. The date of this astounding discovery, March 4, 1771, is one of the most memorable in the history of Japan. The value of western knowledge was established and the Dutch became the scientific leaders. In 1784 Toyo dissected more criminals and wrote the first Japanese book on anatomy, "Records of Viscera." European physiology was introduced in 1836 and from that time on medical literature in all languages was imparted and physicians from Holland, France, Germany and England were invited to make official visits and to teach.

Mathematics

Mathematics of early Japan was the mathematics of the Chinese. The Chinese numeral system, the calendar, the multiplication table and calculating machines, and what stood for algebra and geometry were Chinese affairs which reached their highest stage of development in the eighth century. In Japan it was considered as a game to be played by a few unpractical priests and recluses. Japanese mathematics rose in the seventeenth century as an adjunct to land surveying. From it grew an indepen-

dent system of written algebra, the solution of equations and the treatment of circles. Seki's "Principle of the Circle" is held by some historians as a discovery equal in merit with the invention of Infinitesimal Calculus by Newton and Leibnitz. The astronomical observatory established at Kanda in 1744 yielded material for important contributions to celestial mechanics. From the seventeenth century on the Japanese mathematicians appear to have mingled their science with that from Europe in proportions and values impossible to differentiate.

The facts, principles and methods pertaining to physics, chemistry and to a large degree seismology and volcanology seem not to have been indigenous in Japan. They were bodily grafted onto ideas obtained from the Portuguese, the Dutch, and, after 1868, from the entire world.

Considered as a whole, I hazard the guess that judging from numbers engaged in scientific pursuits and the enthusiastic interest displayed, Japan as a scientific nation ranks next to the United States, England and Germany; something above any other European country and far above Australia, New Zealand, Canada and all South American countries.

And as Japan has energetically played the modern scientific game only during the present generation and many of her outstanding men have, therefore, not reached their prime, and as the crop of enthusiastic youngsters now in training is relatively large, another generation may witness even more favorable ranking.

It has interested me to record certain superficial observations regarding the conditions surrounding scientific research and scientific education in Japan.

Scientific institutions, professional societies, universities and technical schools appear to have been founded in response to demonstrated needs and only after adequate financial support and satisfactory personnel is assured. The scope of the institutions is clearly defined: there is little undesirable duplication and overlap. To a degree unknown in most countries, scientific institutions in Jāpan are financed by pooling contributions from the Imperial Government, from prefectures, from cities and from individuals.

As compared with the United States at least, Japanese professors and scientists are more highly respected and are given better opportunities. Provision for travel and study abroad is common. Japanese scientists are proud of their teachers, honor them; but they also follow their method to an undesirable degree.

Science appears as required study in nearly all educational institutions. Even in the elementary schools, science is taught by men who make much use of direct out-of-door study.

Enthusiasm for study of animals seems much less in evidence than for study of plants and of physical material, and there is a surprising lack of interest in the study of the human race except as history and the development of art. Most of the men who rank as anthropologists are professors of medicine, who treat race problems more or less incidentally.

The botanical gardens of Japan rank with the best. They are many, well planned, well kept, and serve as valuable adjuncts to teaching and research. The zoological gardens and aquaria are interesting but have much less scientific value; they are below American standards. The art museums and historical museums are admirable. They house and display treasures of surpassing interest and value. The natural history museums are few in number and contain little of distinction. Most of them are

miscellaneous collections similar to those used to illustrate lectures in the smaller American colleges.

Japanese science is fortunate in never having to meet the opposition of a religious system. The prevailing religions encourage the search of knowledge in any form, in any direction, to any extent, and Confucius taught that the pursuit of knowledge is the highest expression of human endeavor. I have gained the impression that Christianity would stand higher in the estimation of many educated Japanese if its record for stifling scientific research could be wiped out.

Japanese science, like that among other progressive people of modern times, is partly the result of original thinking but largely the result of developing and adapting knowledge obtained elsewhere. In some branches of science there appears a tendency to accept the leadership of foreign teachers without critical investigation, thus repeating the experience of America with reference to German science during the last quarter of the nineteenth century. Japanese science is "borrowed" in the sense that American science was "borrowed" from Northern Europe and that in turn from Greece and Arabia.

The guiding principle is that expressed by the far-sighted Emperor Meiji: "Knowledge shall be sought for far and wide."

FIG. 1. RESTORATION OF THE DEVONIAN FOSSIL FORESTS FOUND AT GILBOA, N. Y.

In the foreground is seen an idealized reproduction of the rock section at Gilboa, showing the three levels at which fossil stumps were found. The background is a painting of the forest as it probably looked when living, with life-size restorations at either side. This restoration is an exhibit in the New York State Museum, Hall of Fossil Plants. It was executed by the artist and sculptor, Mr. Henri Marchand, and his two sons, Georges and Paul, under the supervision of Miss Winifred Goldring, paleobotanist.

THE OLDEST KNOWN PETRIFIED FOREST

By WINIFRED GOLDRING

NEW YORK STATE MUSEUM, ALBANY, N. Y.

DREAMS do come true, sometimes; and one of the most recent dreams of the New York State Museum was realized when on February 12, 1925, there was formally opened to the public the restoration (see Fig. 1) of the extensive forests that flourished in eastern New York a few hundred million years ago during Upper Devonian (Ithaca) times. The history of the discovery of these trees and the gradual accumulation of material which led to the final solution of their nature is almost as interesting as the ancient trees themselves.

1. HISTORY OF DISCOVERIES

Back in '69, over half a century ago, the little village of Gilboa in the Catskills (Schoharie County) came suddenly into prominence from a paleobotanical point of view. In the autumn of that year the upper valley of the Schoharie Creek was swept by a great freshet which tore out bridges, culverts and roadbeds around the little village of Gilboa. But science, at least, has much for which to be grateful, for at the same time that all this disaster was caused the freshet very obligingly exposed in the bed rock along the creek standing stumps of fossil trees, all at the same level. The discovery of these trees was described in the Albany *Argus* of January 30. 1870, and in the twenty-fourth Museum Report (1872, for 1870); and it was considered of so much importance that it was brought by Professor Hall to the attention of the British Association for the Advancement of Science in 1872. Excavations were made during the year 1870 in the bed of sandstone containing these trees and five stumps and a number of fragments were taken out of this ancient forest. The greater part of this material was brought to the State Museum, where it has for some time constituted a remarkable exhibit of the ancient, extinct flora of the state.

The Gilboa collections were submitted for examination to Sir William Dawson, of Montreal, then principal of McGill College, and in his day an authority on the plants of the Devonian. Dawson placed these trees in a genus of true ferns, represented by trees, and distinguished two species, *Psaronius textilis* and *P. erianus*. The genus has in these later years been thoroughly studied; and it has been found that the structure is quite different from that of the Gilboa trees. Moreover, Psaronius belongs to the Carboniferous, the period of our coal trees, and is much more recent by millions of years than these Upper Devonian trees. The problem of the nature and relationship of our Gilboa trees was still left to science, and seemed incapable of solution until the summer of 1920.

It had always been assumed that our Devonian trees had a scattered distribution—no one dreamed of a vast and extensive forest. The old locality had long since been covered up and the rocks at the level in which the trees were discovered did not outcrop again in this area. Nothing more was heard of these fossil stumps until in 1897, when Professor C. S. Prosser, then connected with the New York State Survey, reported finding some small specimens, from a higher horizon, lying loose at Manorkill Falls about a mile above Gilboa. Occasional attempts since then to relocate this primeval forest of the Devonian period

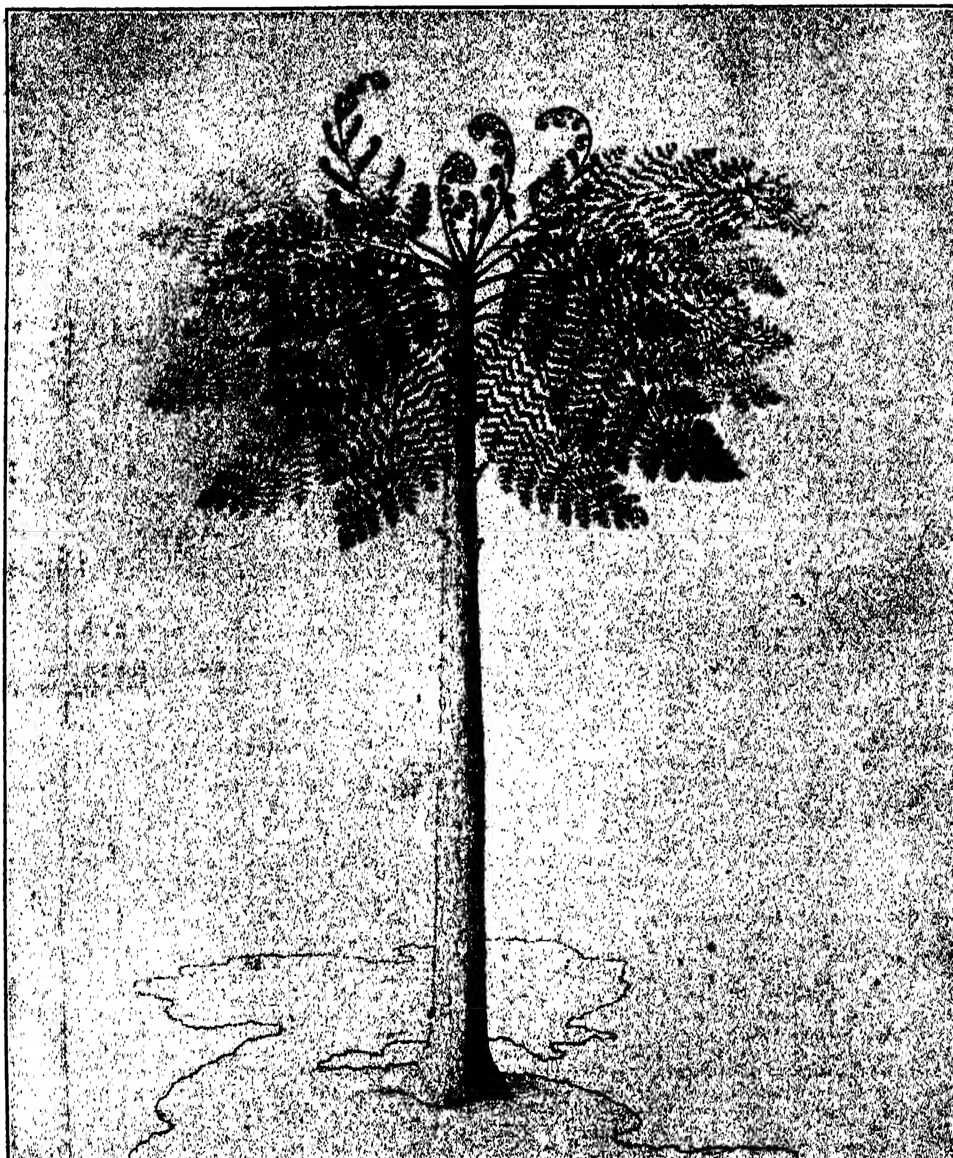


FIG. 2. RESTORATION OF THE DEVONIAN SEED-FERN TREE

SHOWING THE BULBOUS BASE, THE GRADUALLY TAPERING TRUNK AND THE CROWN OF LARGE FRONDS BEARING AT THE TIP, IN SOME CASES, THE SEEDS AND SPORE-BEARING ORGANS. RESTORATION BY MISS WINIFRED GOLDRING.

were fruitless until the summer of 1920, when special effort was made to add to the collection of Devonian plant material already in the hands of the museum. In this year the efforts to relocate the Schoharie forest or to find some additional evidence as to its extent led to the discovery of upright tree stumps not in the original locality but 6,400 feet south, at the higher level along the road in the vicinity of the lower falls of the Manorkill, tributary to the Schoharie Creek (see Fig. 6). Five specimens were taken from this site. These trees, as was the case with those first discovered, were found with their bases resting in a bed of shale, black or greenish-black in color, and representing the original mud in which the trees grew. This tree locality, which constitutes the highest horizon in which these stumps have been found, has an elevation of 1,120 feet above tide, and when the Gilboa reservoir is filled the flow line will be some feet above this spot. The old locality, on the same side of the Schoharie just above the old Gilboa bridge, had an elevation of 1,020 feet A. T., giving a difference of just one hundred feet between these two tree horizons. Since 1920 the city of New York has been doing construction work at Gilboa, preparatory to impounding the waters of the Schoharie Creek for the future use of its citizens. The resultant reservoir will extend over a length of nearly seven miles and will drown the village of Gilboa and its vicinity, including the two above-mentioned fossil tree localities. In 1921, in the course of quarrying in connection with the work on the dam, the old locality, which is directly at the spot where the dam was being built, was uncovered and seven stumps were found, some of them too badly broken to permit removal. One specimen taken weighs nearly a ton and has a circumference of nearly twelve feet (diameter about four feet). In a quarry about half a mile (2,300 feet) down stream from the old locality, trees were found at a level of 960 feet above tide, 60 feet below the oldest or middle locality, 160 feet below the highest level where trees were found. This quarry, known as "Riverside Quarry" (see Figs. 4, 5), has yielded the greatest number and also, on the whole, the largest stumps found. During one period, eighteen specimens were taken from an area fifty feet square, not counting those destroyed in quarrying. One of the largest specimens of this group has a circumference at the base of approximately eleven feet (diameter approximately 3.5 feet), a height of twenty-two inches and a diameter at that height of twenty-one and a half inches; stumps of greater height, but of smaller girth, have been obtained. At all the three tree horizons the stumps were found with their bases resting in and upon shale and in every case in an upright position with the trunk extending into the coarse sandstone above. The shale beds representing the muds in which the trees stood vary in thickness from six inches to two feet, more often thin than thick.

By the spring of 1924 with the additions to our collection, which we owe to the courtesy of the commissioners of the New York Board of Water Supply and the various engineers connected with the work, we had in our museum a total of nearly forty stumps, partial or complete, and a number of broken pieces. We have not added to our number of fossil trees since then; but they have been distributed among various museums and some even have gone into private hands. Taking into consideration with all these, those still at the quarry, the weathered stumps discarded, and those destroyed in quarrying, the number of stumps taken from these primeval forests must run into the hundreds, and continued quarrying will bring more to light. "Riverside Quarry" is not included in the area covered by the Gilboa reservoir, but its

FIG. 3. THE LOWEST FALLS OF THE MANORKILL, GILBOA, N. Y.
THE HORIZON WHERE THE SEEDS AND SPORE-BEARING ORGANS WERE FOUND IS AT THE LEVEL MARKED WITH A CROSS; THE AREA WORKED EXTENDED SOME DISTANCE TO THE RIGHT.

value as a fossil tree locality will be greatly lessened with the cessation of quarrying operations. Now that the rock layers containing the stumps have been located, it is quite possible that they can be traced around the hills and found outcropping elsewhere. In the area known, the tree localities have been found stretching over a distance of something more than a mile and two thirds. No forest as old and as extensive as this has anywhere been reported up to date. We therefore have in eastern New York, up to date, the oldest known forest in the world, and in our museum a unique and unmatchable exhibit.

Except for the discovery of the seeds, which was quite accidental as many very important discoveries are, we would still have been left with a forest of fossil stumps and have been little better off than were Professors Hall and Dawson in 1869. By the merest chance, Dr. Rudolf Ruedemann, state paleontologist, who was on the ground with some other collectors in the summer of 1920, came across a slab of dark shale containing seeds along the edge of the Schoharie Creek in the vicinity of the Manorkill Falls (see Fig. 3). The slab was traced to the bed of shale from which it was derived and a number of good specimens were obtained. Later in that summer the writer and an assistant worked this bed of shale and a fairly large collection of excellent material was obtained, including not only the seeds, but another kind of fruiting body, bits of foliage and roots. Further efforts in the summer of 1923 led to the discovery of a new locality about thirty feet south of the original exposure, and in this and the following year our already unique collection was considerably augmented in both quantity and quality. Collecting in the spring of 1925 showed both localities to be practically exhausted, and besides this whole area will eventually be under the deep waters of the Gilboa reservoir.

In addition to stumps, portions of the trunks of these fossil trees were found in 1920 and later. In the early summer of 1923 bases of stumps were found in "Riverside Quarry" with the long, radiating strap-like roots attached, so that there could no longer be any doubt that these trees grew *in situ*. In 1925 three specimens of the outer bark showing petiolar scars were brought in by Mr. R. Veenfliet, Jr., a local collector. The greatest numbers of the trees comprising these ancient forests were of this "Gilboa" tree type, but evidences of two other kinds of trees have been found. One is a Protolepidodendron, a lycopod-like tree, similar to the Naples tree, Protolepidodendron primaevum (Rogers), known for so many years from the Portage beds of central New York. This tree has not yet been described. In the fall of 1925 two specimens of another type of tree with long, grass-like leaves on the trunk were collected in "Riverside Quarry," and they have been described under the name Sigillaria ? gilboensis (N. Y. State Museum Bull. 267, 1926) as another lycopod type of tree.

In the early summer of that year a rootstock was found in the same quarry, which may belong to either of the last two mentioned types of trees.

2. Upper Devonian Geography and Present Geology

The Gilboa trees afford an index to the geography of the western Catskills and the Schoharie valley during the late Devonian period to which they belong. During these times, the present Catskill

FIG. 4. RIVERSIDE QUARRY, GILBOA, N. Y.

THIS QUARRY IS LOCATED ALONG THE SCHOHARIE CREEK, ONE HALF MILE BELOW THE DAM. FROM THIS QUARRY WAS TAKEN THE STONE USED IN THE DAM AND THE GREATEST NUMBER, AND THE FINEST, OF THE FOSSIL TREE STUMPS. THIS CONSTITUTES THE LOWEST TREE HORIZON AT 960 FEET ABOVE TIDE.

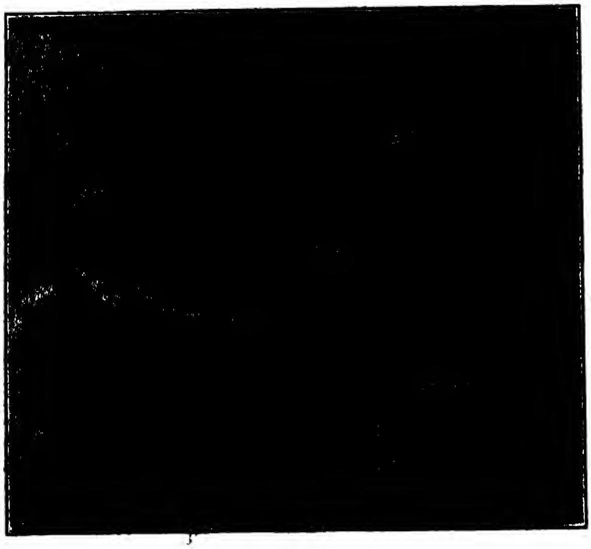


FIG. 5. FOSSIL TREE STUMP IN RIVERSIDE QUARRY

BEING REMOVED FROM THE SPOT WHERE IT HAD RESTED FOR MILLIONS OF YEARS.

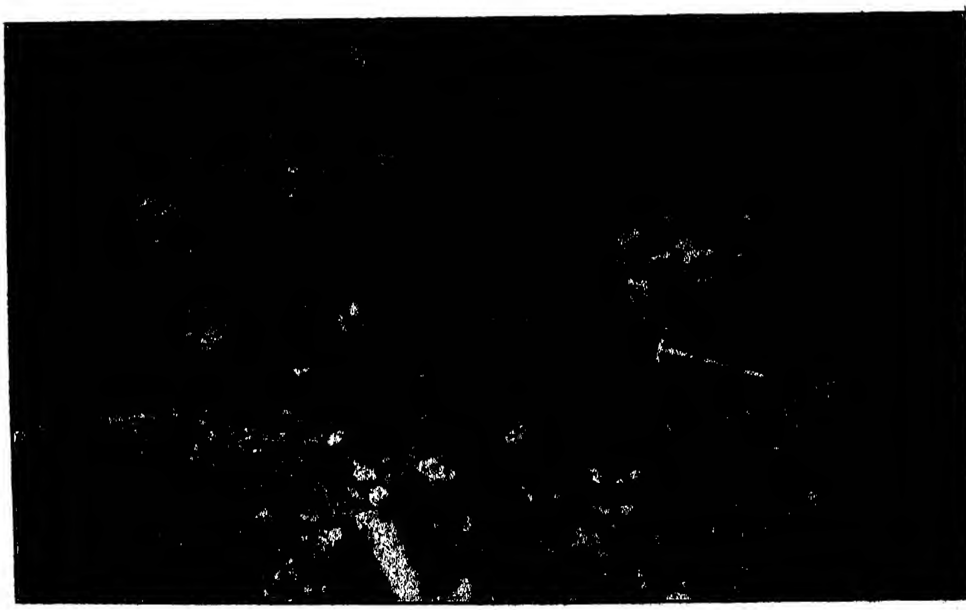


FIG. 6. FOSSIL TREE STUMP

IN PLACE AT THE HIGHEST TREE HORIZON AT 1,120 FEET ABOVE TIDE, ALONG THE ROAD ABOVE THE LOWEST FALLS OF THE MANORKILL. THE MIDDLE HORIZON (1,020 FEET ABOVE TIDE) IS AT THE SITE OF THE GILBOA DAM.

Mountains formed the low shore-line of a shallow sea; and the continental land lay off to the east of the Catskills, extending far into the present area of the Atlantic. This shallow sea covered the interior of the state and country and received the heavy drainage from this eastern land mass. The southwesterly flowing rivers brought down débris of the primitive vegetation with which that lost land was wooded, and scattered the remains, leaves, stems, branches, etc., through the vast delta and shore deposits. Perhaps nowhere else in the known records of the rocks is there such an extraordinary accumulation of the land flora of this geological age as in these sands which underlie the slopes of the Catskills westward into the Alleghany plateau. Plant remains were mingled with the earliest of the fresh water mussels which burrowed in the sands of the river mouths; at times the rivers carried the forest growth far out among the marine deposits and it was mingled with the animal remains of the salt sea. This close intermixture of terrestrial and marine conditions is most abundantly shown in the lower or earlier part of the Catskill terrane. The coasts of those days were very unstable, which would give a swampy shore-line. Forests of primitive trees grew along these shore-lines, spreading down to the water's edge. Gradual submergence of the coast carried these trees beneath the water and the sediments piled up over their bases. At a later period when the sinking basin was again filled by deposits the forest again crept down to the water's edge. The discovery of these horizons of fossil tree stumps shows that three successive forests flourished here, were submerged, destroyed and buried. The fact that the stumps are buried in a fairly coarse sandstone indicates a rapid destruction and burial.

The geologic horizon of the occurrence of the Gilboa trees apparently is the Ithaca formation. The Oneonta is characterized by red beds and they are not found as low as any horizon containing tree stumps. Red beds characteristic of the Oneonta are seen a few feet above the highest tree horizon at the Manorkill. Collections made at a higher horizon four miles to the south at the intake of the tunnel show a prevailing Ithaca fauna; and it is therefore apparent that we have an intermingling of Ithaca and Oneonta sediments. The fresh-water unio, *Amnigenia catskillensis*, occurs in a massive sandstone one and a half miles northeast of Gilboa, some 600 feet above the level of the Schoharie Creek at Gilboa, which clearly indicates that the horizon of this shell is above that of the tree trunks found at Gilboa. The Ithaca fauna is also present on the hillsides above Gilboa; and all this indicates that we have in this area an interfingering of the Oneonta and Ithaca sediments.

3. Structure of Gilboa Trees

A full, technical description of the Gilboa trees may be found in a previous article by the writer (N. Y. State Mus. Bull. 251, 1924, pp. 50–93) by those who care to go into more detail than is given in the following description.

The stumps taken from the three horizons show great variability in size and some variability in shape (see Figs. 7, 8). The bases of the stumps are bulbous, as might be expected of certain trees growing under swampy conditions, and show a circumference at the base from three feet and less up to nearly twelve feet (diameter less than one foot to nearly four feet). In general, the height at which the trunks were broken off varies from a few inches over one foot to about three feet or slightly over, but in the spring of 1925 a large specimen was taken from "Riverside Quarry," which extended up into the trunk for five and a half feet. Some of the stumps narrow quite gradually from the

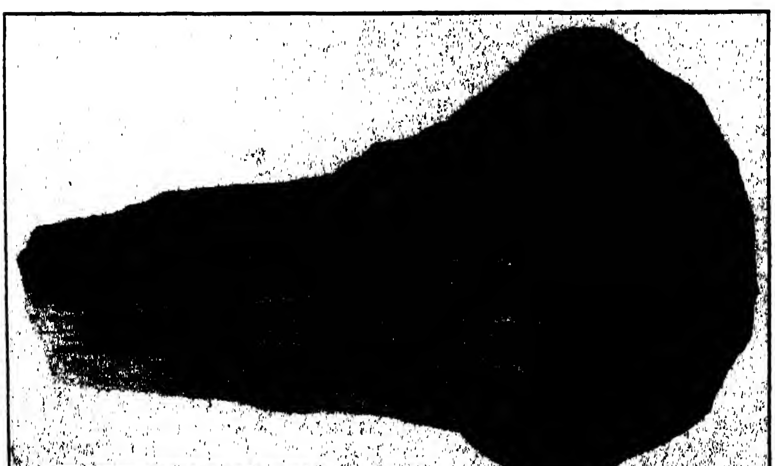


FIG. 7. FOSSIL STUMP OF THE *TEXTILIS* TYPE

SHOWING RAPID NARROWING ABOVE THE BASE AND THE NETWORK OF INTERLACING STRANDS OF STRENGTHENING TISSUE. HEIGHT ABOUT 3 FEET; CIRCUMFERENCE AT BASE 6 FEET 3 INCHES (DIAMETER 23.8 INCHES).

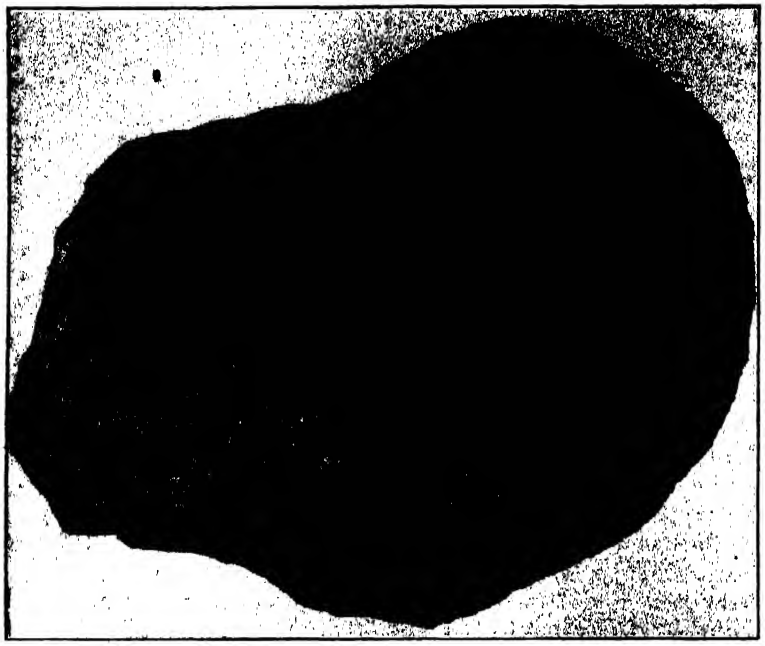


FIG. 8. FOSSIL STUMP OF THE *ERIANUS* TYPE

SHOWING THE MORE OR LESS PARALLEL STRANDS OF STRENGTHENING TISSUE. THE STUMP NARROWS GRADUALLY ABOVE THE BASE. HEIGHT 38 INCHES; GREATEST DIAMETER (LEFT TO RIGHT IN FIGURE) 38 INCHES; DIAMETER AT RIGHT ANGLES TO THIS 30 INCHES.

bulbous base into the trunk, others very abruptly. The parts of trunk above the heights shown in the stumps, which have been found infrequently, are in a flattened condition. The museum has two of these specimens, one over four feet long and the other over three feet long. In the case of the latter, which was taken from the underside of an overhanging ledge, as much again of the trunk had been broken away and lost; and, beyond the section obtained, the trunk continued into the solid rocks with little, if any, diminution in width. Another specimen, too poor to be removed from the rock, showed some twelve feet of slender trunk which must represent a portion near the top of a large trunk or the trunk of a very small tree. Judging from the stumps and the portions of trunks, the largest of these trees must have reached heights of thirty to forty feet.

The outer cortex is the only structure of the stumps and trunks of these trees that is to any extent preserved. The interior structures have been washed out and the cavity left filled with sand which has helped preserve the shape of the stumps in fossilization. The structure of the outer cortex is similar to that seen in a group of Carboniferous seed-ferns (Lyginopteris, Heterangium). It consists of interlacing strands of strengthening tissue (sclerenchyma), forming a network or more or less parallel (see Fig. 9). In transverse sections, unlike the Carboniferous forms, the sclerenchyma appears in the form of dots or short thick irregular lines, irregularly scattered. This zone of the outer cortex varies from an inch or less to several inches in thickness, depending upon the size of the stumps. In the majority of cases, the outside portion of the outer cortex is missing, but it is well shown in several cases. The outer surface is marked with shallow ridges and furrows, in some cases giving the effect of a bark; in other cases the outer surface is only irregularly furrowed and wrinkled or even just roughened, some of which is undoubtedly due to shrinkage in preservation; but in either case the outer surface appears to be composed of layers of sclerenchyma forming a kind of bark, which in the living tree probably had a covering of ramentum or fibers. The underside of the base of the stumps (see Fig. 10) is quite strikingly furrowed in a radiate manner, and in some specimens a depression is seen at the center. The base as well as the sides has the outer zone or covering of sclerenchyma layers above which is the zone several inches thick, varying according to the size of the stumps, of interlacing sclerenchyma strands.

The interior structure of the trunk for the present remains unknown. A transverse section of one of the smaller trunks shows toward the center an irregular, thin ring of sclerenchyma tissue and within this ring and to some extent outside are irregularly scattered strands of sclerenchyma tissue. The scattered sclerenchyma strands may be due entirely to some maceration before preservation; but the ring itself appears to be a definite zone, part of a missing central cylinder of strengthening tissue. Transverse sections of larger trunks were made, but nothing was found. Success in this line can probably only be attained when a petiole or rachis of a frond is found preserved in such a condition that thin sections can be made for study.

In the earlier collections specimens of roots were found, but no stumps were taken with roots attached. This brought forth criticism of our statement that the stumps were buried *in situ*. The discovery in the spring and early summer of 1923 of specimens showing the underside of the tree bases with roots attached (see Fig. 11) finally settled the question. The roots are long and strap-like and radiate from the margin of the base. One specimen was obtained under difficulties and set up in concrete to form a

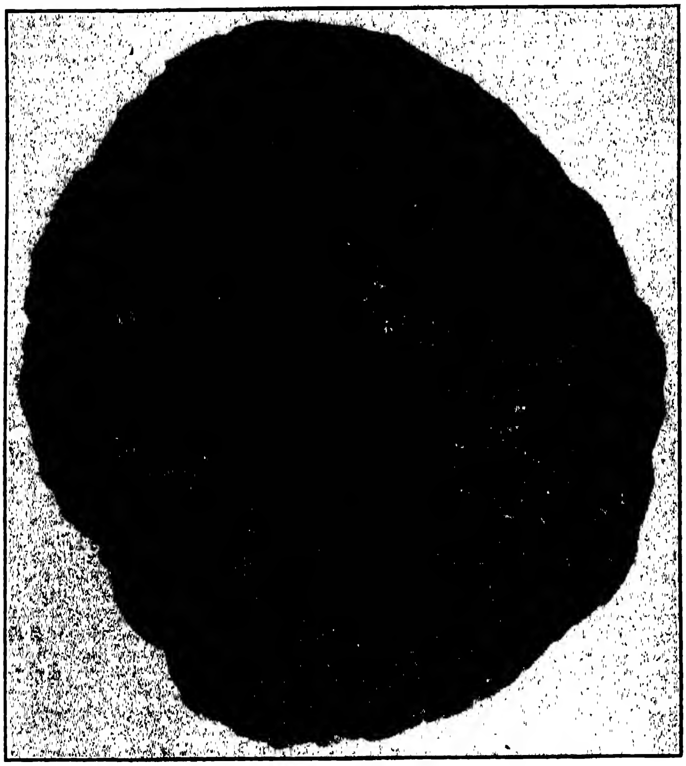


FIG. 10. UNDERSIDE OF BASE OF STUMP OF *TEXTILIS* TYPE
SHOWING RADIATING RIDGES AND FURROWS AND THE CENTRAL DEPRESSION. DIAMETER 25 INCHES.

FIG. 9. PORTION OF OUTER CORTEX OF ONE OF THE STUMPS
SHOWING THE NETWORK OF INTERLACING STRANDS OF STRENGTHENING TISSUE, OF THE TEXTILIS TYPE OF STUMP. SLAB ABOUT 15 INCHES LONG.

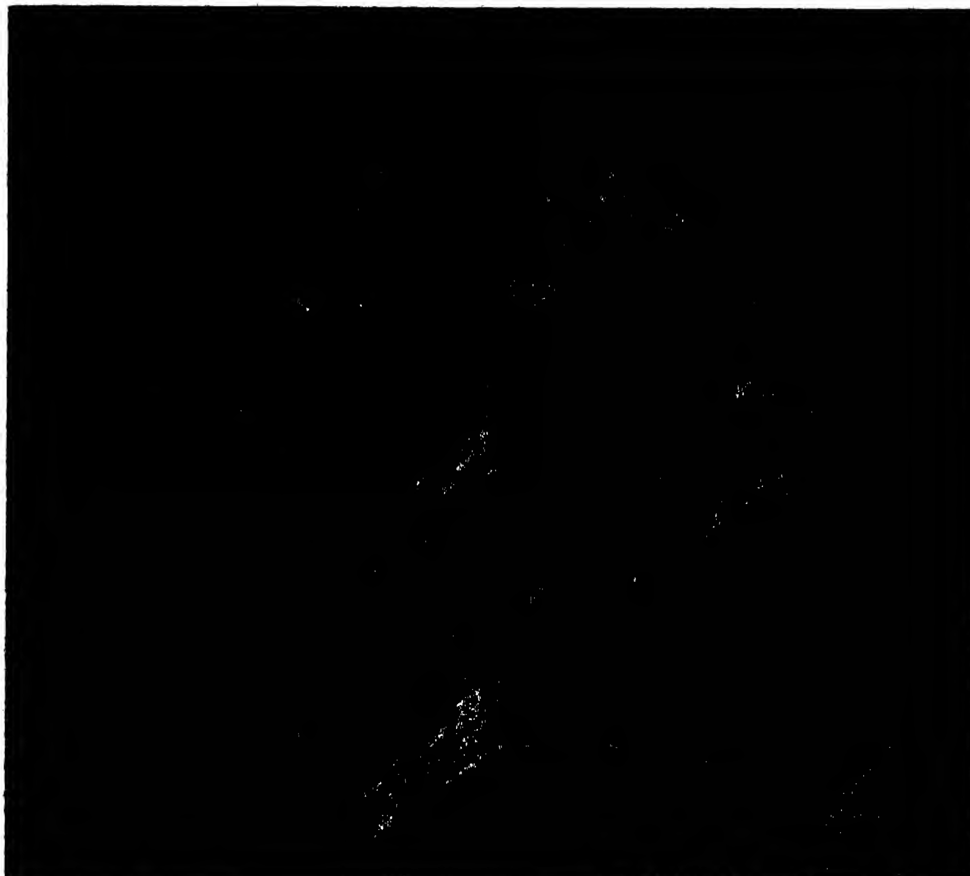


FIG. 11. UNDERSIDE OF BASE OF SMALL STUMP
SHOWING THE RADIATING STRAP-LIKE ROOTS. STUMP 14 INCHES IN DIAMETER. SLAB 6 FEET 4 INCHES BY 5 FEET 7 INCHES.

museum exhibit, through the kindness of Mr. Henri Marchand, who was then working on the Gilboa restoration. The slab, as exhibited, measures five feet seven inches by six feet four inches. The base of the stump is about fourteen inches in diameter, and the radiating roots, from one half inch or less in width to around an inch, extend without termination as far as the rock is preserved. From a study of this and other specimens it appears that the roots were undivided. Much larger specimens were found in the quarry with roots at least nine feet long, but it was impracticable to get them out. The museum specimen is in sandstone, seen from the under side; but other specimens were found on the dumps some time later, showing the impression of the root base in the shale bed beneath the sandstone, often with the radiating roots well shown. The shale bed, as pointed out previously, represents the muds in which the trees grew.

The fronds of the Gilboa tree are compound, tripinnate (three divisions), and judging from the fragments and larger specimens collected, were at least six to nine feet long (see Figs. 12, 13). The pinnules were bilobed, with the lobes slightly recurved. The impression

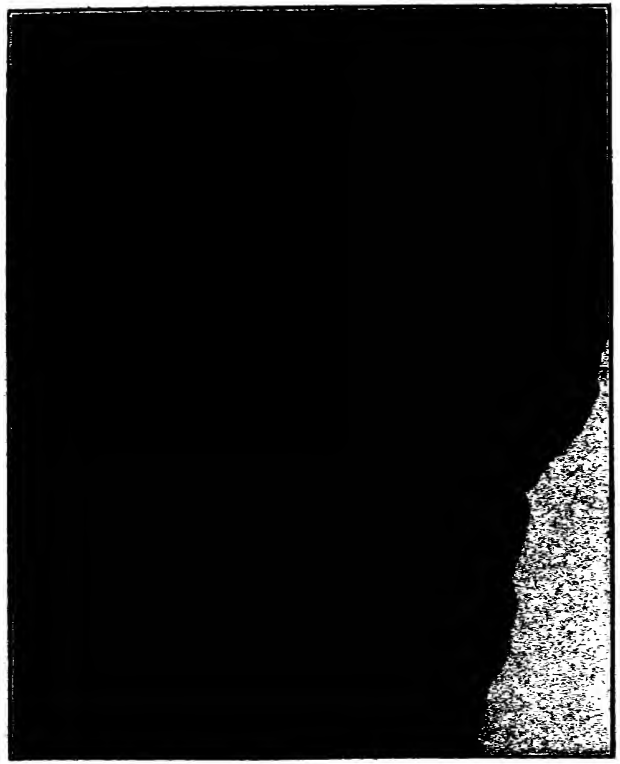


FIG. 12. PORTION OF A FROND
SHOWING ULTIMATE DIVISIONS WITH PINNULES. THE PINNULES OR LEAFLETS ARE SET RATHER FAR APART. THEY ARE BILOBED WITH THE LOBES SLIGHTLY RECURVED. NATURAL SIZE.

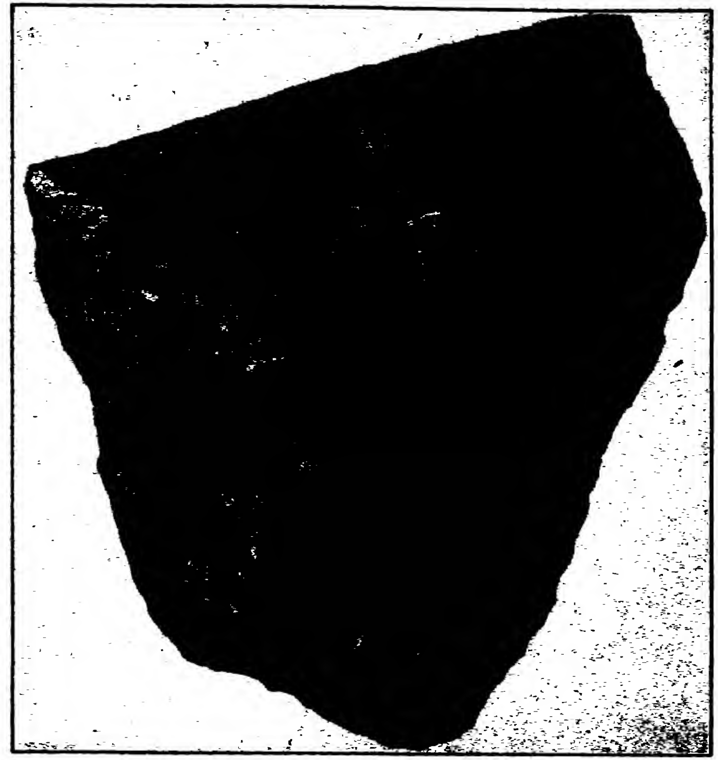


FIG. 13. PART OF MAIN STEM, OR RACHIS, AND LATERAL BRANCHES OF FROND
THE FRONDS HAD THREE DIVISIONS AND MUST HAVE BEEN 6 TO 9 FEET IN LENGTH. GREATEST WIDTH OF SLAB, 2 FEET.

of the main rachis or stem of the frond in the widest part varies from three eighths inch to five eighths inch in the larger specimens. Both the primary and secondary divisions are alternately arranged. The petioles are described as slender and much expanded at the base and spirally arranged in about five ranks. Specimens of outer bark showing petiolar scars were collected in the summer of 1925; but, as yet, the museum has not located any specimens of trunks showing the attachment of the petioles. About 1870 or 1871 a Mr. Lockwood, of Gilboa, found the upper part of one of these trunks, with its leaf scars preserved and petioles attached. The specimen was described by Sir William Dawson as probably the upper part of one or the other of his species of Psaronius found in the same bed.

The seeds of this Upper Devonian tree (see Fig. 14) bear a strong external resemblance to those of the Carboniferous seed fern, *Lyginopteris oldhamia,* and to other Lyginopterid seeds. They were borne in pairs at the end of forked branchlets and were probably borne near the tip of the frond. Sometimes the dichotomies are such a short distance apart as to bring, frequently two, sometimes three, pairs of seeds close together, giving a clustered effect to the seeds. The seed is broadly oval (measuring in the larger specimens 5.3 mm x 2.5 mm to 6.4 mm x 3.4 mm) and inclosed in an outer husk or cupule, which in some cases appears to be lobed. Separate nutlets were found. They occur in groups of small, rounded, thick bodies.

The second type of fruiting body found has been interpreted to be part of the male fructification, a sporangia-bearing organ (sporangiophore), though no separate sporangia have been found. These sporangia-bearing organs are modified pinnules; they are rounded-oval, saucer-shaped to funnel-shaped, and are borne on branching pedicels. It is believed that the sporangia were clustered and attached to the underside of the sporangiophore near the place of attachment of the pedicel and extending out toward the margin.

The two species described by Dawson were distinguished by the arrangement of the sclerenchyma strands of the outer cortex which he interpreted as aerial roots; and to-day the species can stand only on those characters upon which they were originally separated, since we have discovered nothing further to add. His *"Psaronius" textilis* (Fig. 7) is distinguished by a network of interlacing strands of sclerenchyma and *"Psaronius" erianus* (Fig. 8) by more or less parallel strands. Only one kind of foliage has been found; also only one type of seed and male fructification. It would appear then that only in the internal structure of the trunks could these two species of trees be distinguished while living; for if the two species differed in foliage and fructifications, with all the collections that have been made, some evidence of this would have come to light. There may, however, be another explanation of this. The fact that stumps of the *textilis* type have been found in numbers greatly in excess of those of the *erianus* type may account for the collection of only one kind of foliage and fructification, especially since the localities from which the collection of this material was made were few and of limited extent.

4. Description of Forests and Restoration

By June, 1922, after more than half a century since their first discovery, we were in a position to place our trees in their proper relationship and to attempt a restoration. These Gilboa trees in general appearance must have resembled the tree ferns of the tropics to-day, and also of the ancient Carboniferous and Upper Devonian times. The Gilboa

FIG. 14. SLAB SHOWING GROUPS OF SEEDS

THE SEEDS WERE BORNE IN PAIRS AT THE END OF FORKED BRANCHLETS AND WERE PROBABLY BORNE NEAR THE TIP OF THE FROND. NATURAL SIZE.

trees, however, do not belong in this group; they were higher types (seed ferns or Pteridospermophytes) standing in a position between the tree ferns and higher seed plants, and they differ from the true ferns in the possession of seeds and in the higher organization of the trunk. Since the name *Psaronius* had to be abandoned for these seed ferns, a new genus was created, *Eospermatopteris*, meaning "dawn of the seed fern" (from the Greek: eos—*dawn*; sperma—*seed*; pteris—*fern*), and the two species now stand as *Eospermatopteris textilis* (Dawson) and *E. erianus* (Dawson).

As already pointed out, these trees grew along a low swampy shore. They probably reared themselves to heights of at least twenty-five to forty feet and bore fronds at least six to nine feet in length, on the tips of some of which were borne the seeds. The bulbous base undoubtedly was buried in the swampy mud for some distance, as the roots are not heavy and the tree otherwise would not have adequate support. The foliage of the trees was not heavy, much looser than in the tree ferns of to-day and the pinnules or leaflets were far apart (see Fig. 2). There would have been no dense shade in this primitive forest; except perhaps for the heavy moist atmosphere sunlight could easily filter through. No higher forms of life existed there. The hum of insects was not heard, for there were no insects here at that time. All the sounds one would hear could one have been in that ancient forest would be the murmuring of the winds in the tree tops or sounds from the neighboring sea or at times the howling of destructive storms. Three such forests, undaunted, reared themselves in all their glory, were cut down by the sea, buried and fossilized.

The restoration of the Fossil Forests of Gilboa (see Fig. 1) was executed by the artist and sculptor, Mr. Henri Marchand, and his sons, Paul and Georges, under the supervision of the writer. As shown in the accompanying photographic reproduction, it includes an idealized reproduction of the Gilboa area, showing the three forest levels, and here the actual fossil stumps are used. In the center foreground flows the Schoharie Creek, which is joined at the left in a series of falls by a tributary, such as the Manorkill. Looking across and beyond this fossil section one sees the painting of our vision of this ancient forest as it might have looked in the height of its glory. The lycopod-like trees (*Protolepidodendron*), which grew in small numbers in these forests, are also shown in the painting. At both sides of the painting are life-size restorations of the Gilboa tree, which merge imperceptibly into the painting. The artist has depicted so understandingly and skilfully the character of the forest with its heavy moist atmosphere that this restoration is at the same time both a scientific reproduction and a beautiful piece of art.

REFLECTIONS ON CREDULITY

By Professor A. W. MEYER

DEPARTMENT OF ANATOMY, STANFORD UNIVERSITY

Although the rôle of scepticism looms large in the discussion of the intellectual development of man and the history of civilization, its twin sister, credulity, goes almost unnoticed. This fact probably can not be accounted for by saying that nobody knows what credulity is. We know no better what scepticism is, and there has been no end of discussion of consciousness, of mind, of life and of the soul. Yet who ventures to say what they are? Only the parvenu among modern physiologists, philosophers, or what not, attempts that. It is not my purpose to trace the history of credulity, to account for its changing prevalence, or to determine its rôle in civilization. That must wait for those fitted for the task. I merely wish to call attention to some matters of interest in connection with the question.

It seems that one may speak of waves of credulity and that these often have been associated with periods of emotional strain and stress. We ourselves are not yet through the one we entered with the Great War. Every one finds it difficult if not impossible to think calmly in times of great emotional appeal. It is this which makes tolerance in war and religion so difficult. As Sir Thomas Browne well said: "Men have lost their reason in nothing so much as their religion (and he should have added war) wherein stones and clouts make martyrs; and since the religion of one seems madness unto another, to afford an account of the rational of old rites requires no rigid reader." Nor is it only religion and war of which this is true. It holds for anything regarding which men feel strongly, and it is recorded that artificially produced emotional excitement is used among primitive people to stimulate belief in magic and animism, for incantations increase suggestion, heighten the illusion and hence forestall scrutiny and criticism.

Credulity is so prevalent even to-day as to escape comment. Indeed, it is the rule, scepticism the exception. We take conformity in all things for granted; non-conformity only attracts attention. This probably always has been and probably always will be so. But if this be true, then it must follow that man is far less a reasoning being than he has prided himself upon being and that most people still walk by faith rather than by sight.

Most thinking is haphazard and sound thinking an art which few acquire. We become reasoners only through painful experiences. We are born into, bred for and later yield to, if we do not actually strive for, conformity. Mass treatment and mass production also impose it. Our religious, our political and our scientific beliefs are prepared for us. We are bred dogmatists and only the Galtons protestingly ask: "Are we to understand that it is the duty of man to be credulous in accepting whatever the priest in whose neighborhood he happens to reside may say? Is it to believe what his parents lovingly taught him?" We grow up to accept things as they are, and credulity ever has forged the chains which scepticism later has had to break. Few indeed are they who shatter its bonds early and strike out boldly for themselves.

Conceptions which constitute credulity to-day may have been regarded as wisdom but yesterday. Yet the mental attributes which characterize a credulous person probably have remained the same and so have the criteria by means of which we judge it. The nature of credulity is unchanged and so no doubt is its cause. The credulous have formed a large group in all ages, but we are born neither credulous nor incredulous and one can not rightly speak of an instinct of credulity. One can be born credulous only in the sense that he lacks mental acumen, curiosity or initiative and it surprises one that Ward referring to Bain spoke of a "primitive credulity" as the leading fact in belief, and that James spoke of "a primitive impulse to affirm immediately the reality of all that is conceived."

Credulity is characteristic of the childhood of man and of civilization, and one might perhaps use its prevalence as an index of the intellectual status and perhaps also of the happiness of a people! Childhood is generally conceded to be a happy and a pleasant state, hence the more credulous a people, the happier it ought to be. A credulous man has few perplexities. "Is it not true," asks Pascal, "that man must be ignorant of the science of geometry if he is to be happy?" Erasmus, writing ironically, spoke in a similar vein when he said, "If anything could be known for certain would knowing it not interrupt and abate from the pleasure of a more happy ignorance?" However, we count those days great in the history of civilization in which the bonds of credulity were broken quite generally and new conceptions began to dawn upon the favored few among men.

We habitually associate credulity with ignorance and usually speak of an ignorant and a credulous age with pity. Perhaps, some happy day we may have the wisdom to erect monuments, in our hearts at least, to more of the pioneers of those great enlightening epochs in human progress when the emancipation of the human mind went forward apace —epochs in which links in the chains which man had forged for himself were broken, thus enabling men to speak freely even if they did not think very deeply or speak very wisely. It is not necessary, for example, to unqualifiedly accept the feeling of Rabelais regarding the preaching of his day in order to admire his audacity in declaring: "The less said the better. I never sleep at my ease except when I hear a sermon or when I pray to God." It means much indeed for his time that he dared speak out, although Rabelais was an anatomist and physiologist as well as a literary man and hence perhaps unduly unresponsive.

It is not credulity regarding theological matters that has a special interest for me, although, to be sure, credulity in science often is a twin sister of credulity in theology. Although theology and science do not necessarily deal with the same topic, "many of us are taught from earliest childhood to invoke the saints" to further our own ends.

Credulity in scientific things has not been limited to those unacquainted with science. Nor have churchmen lacked scepticism regarding scientific matters. Men in the shelter of the church like Boyle and Newton maintained an encouraging scepticism regarding scientific matters. Others, like Pascal and Steno, were sceptical at first, then fell under the sway of theology and ended their scientific careers prematurely. Still others, like Sir Thomas Browne, were grossly credulous at first and unusually sceptical soon thereafter regarding the same things but without severing their relations with the church.

Environment no doubt played a part,

a very important one, in Browne's case, for it probably was the "Zeitgeist" which saved him. In Pascal's case, however, it was not only through the spirit of the times that his great intellect was lost to science, but through an intense desire for happiness which science did not seem to vouchsafe him, for he declared, "I spent a long time in the study of exact sciences, and I was disgusted to find how little compensation one can find in it. When I began the study of men I saw that they were not suited to it, and that I had wandered further from my proper condition in investigating them than the others had in neglecting them." But the difficulty lay not in science, for Kepler, Galileo, Newton and a host of lesser men found their greatest happiness there. The difficulty in Pascal's case probably was due to personal rather than to environmental causes.

Aside from the question of the origin of life and the destiny of man, there is no sphere in which credulity has played and still plays a larger part than in regard to health and disease. It is pitiable that such deep credulity persists regarding these matters even to-day when so much that is reliable is known concerning the human body and the infirmities from which it suffers. This so impressed the late Sir William Osler that in a public treatise, issued shortly before his death, he wrote: "In all things relating to disease, credulity remains a permanent fact, uninfluenced by civilization or education."

Osler repeated the same thought a few pages further on and among other things added: "Precious perquisite of the race, as it has been called, with all its dark and terrible creed, credulity has perhaps the credit balance on its side in the consolation afforded the pious souls of all ages and of all climes, who have let down anchors of faith into the vast sea of superstition. We drink it in with our mother's milk and that is indeed an even-balanced soul without some tincture of it. We must acknowledge its potency to-day as effective among the most civilized people, the people with whom education is most widely spread, yet who absorb with wholesale credulity delusions as childish as any that have ever enslaved the mind of man."

Nor was the medical profession exempted by Sir William, for he declared: "We doctors have always been a simple trusting folk! The blind faith which some men have in medicines illustrates too often the greatest of all human capacities—the capacity for self-deception."

Osler, who had been twitted on practicing medicine with "nux vomica and hope," in referring to organotherapy, wrote: "One is almost ashamed to speak in the same breath of the credulousness and cupidity by which even the strong in intellect and the rich in experience have been carried off in a flood of pseudo-science. This has ever been a difficulty in the profession." Indeed, one need not wonder that the laity far outdo the profession when men of the highest standing—even Academicians—in pure science to-day attest to the most apocryphal cures by pseudo-scientists and outright quacks.

Since St. Augustine well knew what "old wives' tales" were, it surprises one that this learned man believed that the flesh of a peacock never putrefies. Especially so since he derided some of these tales himself and also stated that he in turn was derided by God, "being insensibly and little by little led on to these follies, as to credit that a fig-tree wept when it was plucked, and that the mother tree shed milky tears"; or that "had some saint eaten and mingled with his entrails, he should have breathed out angels; yea in his prayers he shall

assuredly groan and sigh forth particles of God, which particles of the most high and true God should have remained bound in the fig unless they had been set free by the teeth and belly of some 'sweet saint!'" Nor did Augustine believe in sorcery, for he says: "I remember, too, that when I decided to compete for a theatrical prize, a soothsayer demanded of me what I would give him to win; but I, detesting the abominating such foul mysteries, answered that if the garland were of imperishable gold, I would not suffer a fly to be destroyed to secure it to me." Yet, St. Augustine decried the belief in the antipodes and held that touching the bodies of martyrs "preserved uncorrupted for so many years" would heal blindness.

Sir Thomas Browne declared his belief in palmistry, tutelary angels, the philosopher's stone and the reality of witches. This strikes one with surprise, especially because he held that those who disbelieved in witches were not merely infidels, but atheists, adding, in the manner of Tertullian, that he was the more ready to believe a thing the more improbable it was and that the actual impossibility of an alleged occurrence is an evidence of its truth. Yet, but a little over a decade later this able and lovable man asserted in his "Pseudodoxia, or Inquires into Vulgar Errors" that there are only two pillars of truth, experience and reason, and that neglect of inquiry, obedience to authority and credulity are responsible for much error. This sounds strange indeed coming from one so steeped in theology that he had argued in all seriousness but a few years before, that he should not date his age from the day of his birth but from that of his baptism, because he did not exist before then. Although this was a well-known and current theological conception, I can not adopt the attitude of apologists who see nothing contradictory in this attitude of Browne's, for even if the word existence is used in a wholly different sense, to reckon his chronological age from baptism nevertheless remains nonsense. The assumption of water-tight mental compartments can not save it and as Boutroux has well said: "If science and religion are to continue to co-exist, it seems opposed to the conditions of modern thought to admit that this result can be brought about by the so-called 'watertight compartment' system which, at the present time, is frequently extolled and considered possible." A thinker may say so, but it does not therefore follow that he actually can so confine his thoughts. It seems to me that the day never was when real thinkers could "hold religion in one compartment of their minds and their modern world view in another." A daring intellect does not, nay can not, build mental fences for itself.

After discussing a long list of errors of credulity, Browne concluded by saying: "Many others there are which we resign to divinity and perhaps deserve no controversy." He was thirty years old when he wrote the "Religio Medici" and forty-one when he wrote the "Pseudodoxia." It is true that his was not a very outstanding intellect, but he nevertheless was a man of rare parts, of varied learning and of wide experience. Earlier in his career he apparently had followed Bishop Hall's dictum that "not a curious head, but a credulous and plain heart is acceptable with God." His complete about-face can be accounted for by assuming that the times in which he lived shaped his attitude as they do our own. No one is independent of his day, least of all of the present, and it may be recalled that during the war one of our highest government officials declared that the United States had been chosen by God

"to greatly influence, if not to determine, the course of future events." It would be interesting to know whether or not this gentleman held as firmly to his belief in the intervention of the Lord in human affairs after his defeat as a presidential candidate!

Since Pascal assigned a similar crucial rôle, as this politician assigned to our country, to "a little piece of gravel in Cromwell's bladder," we should not, I presume, doubt this confident verdict regarding our country's "manifest destiny." It may be recalled that Luther was afflicted in a manner similar to Cromwell and that the removal of his stone too might have changed the course of history. Hence I make bold to suggest that the influence of urinary calculi on history might be a fitting subject for some young aspirant for the doctorate.

In Browne's case the change in mental attitude was from a condition of extreme credulity to one of frank inquiry; in Pascal's case it was the reverse. The difference in the result, it seems to me, does not lie wholly in the differences of the times, but largely in the men themselves. I am reminded, however, that Matthew Arnold held that the differences of opinion and character in men are not organic, but wholly the result of a difference in environment. But fortunately there are innately curious just as there are innately confiding individuals. "Some men and thinking men too," says Buckle, "never have those vexing thoughts" of doubt. They close the door of doubt, or better never open it. They do not give "stabbing truths" a chance to affect them, but rather "trust in false things and nourish the wind," as St. Augustine said.

Carlyle thought that "there are only a few reasoning mortals, here and there," and Mill in his diary declared that there was neither thought nor knowledge in England. He declared: "The characteristic of Germany is knowledge without thought; of France, thought without knowledge; of England, neither knowledge nor thought."

"The Germans, indeed, attempt thought, but their thought is worse than none. The English, with rare exceptions, never attempt it. The French are so familiar with it that those who can not think at all threw the results of their not-thinking into the form of thoughts."

It may be recalled that Lecky held that it was not arguments, but habits of thought resulting from common sense, that overcame the belief in witchcraft. But common sense surely is the product of experience and of reason based upon it. New habits of thought can arise only on the basis of new experiences, or from desires in answer to needs. It does not seem possible that a whole people is likely to, or even can, change its habits of thought in any brief period of time, save through a great and universal experience, for deep thinking is not a universal trait of mankind. It takes resolution and effort to think and there is considerable truth in the statement of a recent writer that "most people would rather sicken and die than think," and he added, "they do." Indeed, "it is much easier to believe than to doubt, for doubt connotes thinking and the expenditure of energy and often also the disruption of the status quo."

Few of us can break the chains that bind us, and still fewer wish to do so; and after all perhaps Shaw was right when he said that the cleverest man will believe anything he wishes in spite of all the facts in the world. However, I have never felt much sympathy with the old saying: "Populus vult decipi," for every one but a fool resents being trifled with. Worthless stock causes rejoicing only as long as its true nature remains

unknown. People like to deceive themselves only regarding unwelcome things, and then only provided that the truth or reality of them can not be established. Did they know for a certainty that disillusionment would follow inevitably and swiftly, few indeed would wish to be deceived regarding anything. No one is flattered by public disclosure of the fact that he has been duped, least of all that he has duped himself, but it is so easy to believe when the wish is father to the thought. I desire to get well, therefore, I will get well. Credulity easily congeals into prejudice, and as Tyndall put it: "The drugged soul is beyond the reach of reason. It is vain that imposters are exposed, and the special demon cast out. He has but slightly to change his shape, return to his house, and find it empty, swept and garnished."

It is especially interesting that religion has often been advanced as a safeguard against credulity, but it would seem more likely that religious beliefs, which are accepted upon authority, must tend to lessen the spirit of inquiry in regard to other matters also. It is reported, for example, that the Baloki had no faith in their medicine men before the missionaries came. Yet, Mill wrote:

"It is sometimes said that religion is the only preservative from superstition; that unbelievers and unbelieving times are the most indiscriminately credulous; 'A godless Regent trembles at a star,' the popular delusions (Mesmer, Cagliostro, etc.) of the time preceding the French Revolution: mesmerism, table-turning, etc., at present. But the truth is, credulity and love of wonder are so natural to man that they always (hitherto) run riot when they have only reason to control them. Credulity has never yet been held in check, but by a regulated credulity—a faith of some sort which excommunicates all wonders but those which it can use for its own purposes. Those who throw off this faith do not thereby become altered in the general texture of their understandings; they remain as credulous as ever, but being no longer preoccupied (and the appetite for wonder blunted) by one set of delusions, they are now open to all others."

Were this true, then all nations must have been very irreligious during the Great War, for anything and everything was reported and believed. We were alleged to have poisons so potent that whole cities could be swept away as with a breath. To hear a rumor was to believe it, to believe it was to accept it as truth, and to accept it was to act upon it quite regardless of the consequences.

In spite of the beneficent fruits of improved means of communication, the introduction of printing, the telephone and telegraph, wireless telegraphy and so forth, these make credulity more contagious, for they not only excite wonder but help to reveal the credulous everywhere and make contact with them and between them easier. Dame Rumor now-a-days moves faster than the wind and times of great awakening, such as the Renaissance, are said to have been followed by epidemics of credulity. Great discoveries create an impression that all things are possible and in the present so-called scientific period, Abrams and Hatfield become popular heroes and the public has little sympathy with scientific disbelief regarding them.

Nor is credulity entirely absent from scientific laboratories. We can grow tissues under the microscope, therefore, we have life in a test-tube. Physiologists talk about colloidal systems and some of them claim to know what life is. If we scientists delude ourselves, why rebuke the masses who are deluded by others most of the time and if it be true as Tout claims "in no period are the critics an exception to the general rule of unthinking credulity," no one would seem to be exempt.

Although there undoubtedly are credulous natures, ignorance seems mainly responsible for the prevalence of credulity in the public and in the individual. This does not imply, however, that educated persons may not be deeply credu-

lous, for no one can know enough to ensure wise action in all things. Safety lies in an awareness of one's ignorance and in relying upon those who do know about matters that one does not. In this lies not only the salvation of the individual but also that of democracy itself. The eclipse and the rainbow ceased to be portents of evil as soon as they were understood. As Hobbes well said: "Ignorance of natural causes disposes man to credulity, so as to believe many times impossibilities; for such know nothing to the contrary, but they may be true, being unable to detect the impossibility. And credulity because men like to be hearkened to in company, disposeth them to lying; so that ignorance itself without malice, is able to make a man both believe lies, and tell them; and sometimes also to invent them." Hobbes's opinion receives some confirmation from Mill, who thought that there is more of lying than of self-deception in spiritualism.

There have been those who have held that credulity is a conserving social force. By doing something to produce rain Hatfield may have lessened the anxiety of some and increased the hope of other ranchers. Ceremonies and prayer during illness or war may accomplish similar results and may keep the idle and anxious occupied and thus protect the rest by keeping the former from mischievous and disturbing thoughts. This may be good doctrine for children and the masses, but let it not be forgotten that organized credulity—as when it licenses cults to deal with public health or opposes the use of the dead for help to the living—is as destructive a social force as was the belief in witchcraft. It was wisely said that "black magic and red religion have been extremely anti-social at all times" and that no "baser delusion (than superstition) ever obtained dominion over the weak mind of man." Indeed, no one can tell what heights the human race might have reached by today had it never been burdened with unquestioning credulity. I presume there should be no unpardonable crimes among men, but if there be such then shackling the human mind should head the list. A sound mind in a sound body is a worthy ideal indeed, but a sound mind is of little use unless it be free, even if it remain true, as Heine thought, that liberty is but a cruel dream.

PROGRESS

By Dr. J. P. SIMONDS

NORTHWESTERN UNIVERSITY MEDICAL SCHOOL

PROGRESS as a biologic and social fact and the idea of progress as a social force are distinct phenomena. The fact of progress is disputed; the idea of progress as a dynamic element in modern society is generally accepted.

It is perhaps significant that the origin of the idea of progress about the middle of the sixteenth century, and the acquisition of its present social potency in the latter part of the nineteenth, was each associated with an event that gravely wounded the pride of the race. Copernicus proved that the earth was not the center of the universe, but a very insignificant part of its own solar system. In 1858, Darwin published his "Origin of Species," ushering in the theory of evolution by which man was degraded from his proud position "a little lower than the angels" to a more humble rank a little higher than the apes.

Before Darwin, man, looking backward over his racial history through the spectacles of a religious dogma, saw a Garden of Eden or some other golden age of innocence and happiness. But with the onset of a sort of racial presbyopia, these spectacles lost their power, and man saw in the long dim vistas of the past not a beautiful garden inhabited by a perfect man and woman, but an uninviting Paleozoic swamp in which ugly reptiles disported their unwieldy bodies. This look into the long past, at first so disconcerting, was not without its useful effect. When he awoke from his dream of a past golden age and became dimly conscious of his own ancestry, the idea of progress took on a new meaning and acquired a strange potency.

Progress began with the appearance of life upon the earth. Whatever the fundamental nature of life, with its advent matter that became living acquired an activity that was largely unpredictable as to direction, mode and strength. The realm of the organic or living was separated from the inorganic or non-living. The inorganic world is intensely dynamic at least within narrow fixed limits of the atom; but it lacks individuality. The organic or living world exhibits spontaneity and an orderly system in the midst of an almost unbelievable multitude of living beings. Individuality, that quality that marks off one being from another of its kind, came upon the earth with life.

The second step in progress was made when living organisms became more complex. Instead of a single cell some of them came to be composed of many cells, some on the surface near the source of supply of nutriment, others in the more central parts where the needed nourishment could reach them only by diffusion through the more superficially located cells. The needs of increasing complexity were met by the formation in the body of different organs, composed of highly differentiated cells and with specialized structure and function.

With the increasing complexity of living organisms and the division of labor among the organs of the body, there entered a new factor of progress, namely, death. Death became a biologic necessity; one of the fundamental determinants of progress. "The sure-enwinding arms of cool enfolding death" are quite different when considered from the standpoint of biology and progress,

from the dreaded, inexorable, dissociating destiny that death becomes to the individual. Goethe remarked that "death is Nature's expert device for producing an abundance of life." To "yearn for speedy death in full fruition" is not an unworthy biologic desire. Swinburne had something of the biologic viewpoint in his "Garden of Proserpine" when he wrote:

> From too much love of living,
>   From hope and fear set free,
> We thank with brief thanksgiving
>   Whatever gods there be
> That no life lives forever;
> That dead men rise up never;
> That even the weariest river
>   Winds somewhere safe to sea.

With the increasing complexity of structure and size of organisms and with the advent of death, life became more abundant and aggressive without being in the way of its own progress. Each living creature leaves behind it an abundance of seed capable of reproducing its kind and making possible useful variations. This is, as Huxley has so graphically said, "a Sisyphean process, in the course of which the living and growing plant passes from the relative simplicity and latent potentiality of the seed to the full epiphany of a highly differentiated type, thence to fall back to simplicity and potentiality again."

Animal life became differentiated from vegetable life, and between these two forms was intercallated the interrelated, useful and even indispensable group of bacteria. With this triad of living types, there was instituted that marvelous chemical mechanism, the nitrogen cycle. Plants developed the unique and potent substance chlorophyll, by which they use the sun's rays to build up very complex chemical compounds from such simple substances as the nitrates, carbonates and water of the soil. In plants, protein, a complex substance which contains nitrogen and is essential to animal life, but which animals are incapable of building up from its elements, became abundant. This made possible the origin, continuance and further evolution of animal life. Animals transform plant proteins into the more complex animal proteins. But animals reach their threescore years and ten or its racial equivalent and die. Bacteria then decompose the complex animal protein, breaking them down into simple nitrates, carbonates and water to be used again by plants. The nitrogen cycle thus became an essential of all further progress.

Other attainments of animal life that have been fundamental factors in this progress are the acquisition of a body, with its component organs, among which the labor of maintaining the various functions of living matter has been distributed; bilateral symmetry of body conducing to greater freedom and better coordination of movements; and the development of a backbone making possible the upright posture, and freeing the fore-limbs for uses other than locomotion. A distinguished paleontologist has described as "the earth's most dramatic moment" that day when the first animal crawled out of the Paleozoic ooze and, by means of a workable mechanism for guaranteeing its oxygen supply, succeeded in maintaining itself on dry land.

Some of the back-boned animals developed a mechanism for regulating body temperature. The temperature of the so-called cold-blooded animals is always approximately that of the medium in which they live and therefore varies with the season and even from day to day. The acquisition of a means of maintaining a constant body temperature avoided the necessity of an animal's being one day alert and active and the next sluggish and inert. This introduced a possibility of progress of incalculable impor-

tance. Upon it depends man's freedom from slavery to changes in the weather, the sequence of the seasons and the variations of climate.

The differentiation of the sexes led to the liberation and education of the emotions; so that men came to love and to hate, to pity and to curse, to feel shame and to express anger, to seek pleasure and to find pain. Animals developed eyes to see and ears to hear and other special senses by which the slowly evolving personality within learned the beauty and the ugliness, the sweetness and the bitterness of its environment.

But the greatest biologic achievement in the possibilities it entailed was the acquisition of a central nervous system. This slowly evolved through an ascending scale, the climax of which has been reached in man with his relatively huge brain incased in a protecting skull, and a long spinal cord inclosed in a protecting spinal column. The cortex of man's brain, if spread out, would cover not more than two square feet, and is said to contain 9,200,000,000 nerve cells, which, if got together, would weigh less than half an ounce. And yet this thin layer of gray matter is "the material theater of man's intellectual life."

The appearance of life upon the earth; the acquisition of a body, especially one with bilateral symmetry; the intervention of death as a biologic necessity; the institution of the nitrogen cycle; the achievement of a mechanism for maintaining a constant body temperature; the differentiation of the sexes; the development of the special senses; the evolution of a central nervous system—these are some of the foundations of biologic progress.

The outstanding feature in all this is an increasing complexity of structure and function that gives to the living organism an increasing capacity for dealing with its environment. The most important of all these elements of biologic progress is the acquisition of a central nervous system, the integrating mechanism by which all the different organs and functions of the body are organized into a homogenous system with unified control. This system, with its increasing intricacy of structure, is the basis of behavior. In the ascending scale of animal life, behavior becomes more and more complicated, acquires more and more the attributes of intelligence and connotes an expanding mastery of environment. With the advent of life upon the earth, the evolution of the multitudinous species of animals and plants began. With the development of the human mind, history, which deals with societies of rational beings, originated. As Thompson remarks, "The great difference between human and animal evolution becomes plain when we observe that man is aware of his own evolution and seeks to direct it according to his own ideals."

The evolution of any species is the result of the interaction of a static factor, heredity and two dynamic factors, variation and selection. There has come down through time a stream of germ-plasm in and through which heredity has operated. It (heredity) is the inertia that tends to prevent change; it is that which causes living beings to reproduce their kind. But in spite of the stabilizing influence of heredity, variations have occurred, giving rise to new species. Variations are of two kinds: those which take origin in the germ-plasm, such as the color of the skin and the shape of the foot, and are therefore deep-rooted and fundamental, and are reproduced in succeeding generations; and those which are due to acquired changes in the body or modifications of its activities without corresponding alterations in the germ-plasm, such as smooth-shaven faces, the performance of certain religious rites, and are therefore not inherited by the

offspring. The former are the foundation of the development of new species; the latter are important factors in the evolution of human society, being transmitted from generation to generation through the force of individual habit and social custom.

Man, as a species of living organism, with his mechanically efficient body and his highly developed and integrated central nervous system and all that they connote, represents unquestioned biologic progress. This is the result of a long series of primary changes based upon fundamental alterations in the prodigiously long stream of germ-plasm extending back at least to the origin of vertebrate types. Man's physical form appears to have become stabilized, so that further anatomical changes seem unlikely. The future progress of mankind must, therefore, be the result of societal as distinguished from biologic evolution. Social metamorphosis has resulted and will continue to result from the action of forces quite different from those which instituted and perfected man's present physical form. Human anatomy is dependent upon the fundamental and not readily changed qualities of human germ-plasm. Social organization is based upon a great body of tradition transmitted at first orally and later by more accurate and permanent written and printed records. Man can not by taking thought add one cubit to his stature, because that is effectively guarded by the laws of heredity and of economy of growth. But he can, by taking sufficient thought and by the exercise of an adequate force of individual and collective will, modify his social system to meet the demands of gradually changing conditions.

The evidence of biologic progress is abundant and convincing, if we consider as progress that series of changes which have enabled animals to live a freer existence, to liberate themselves gradually but steadily from the bondage of their environment, to receive stimuli through an increasing number of sense organs, and to integrate and interpret these sensations through an increasingly complex central nervous system; in other words, to live a life richer in content and more exuberant in expression. But what of social progress? Has anything happened to man as a social unit in an organized society that is at all comparable to what has occurred to him as a biologic unit in the animal kingdom?

The first requisite of human progress as distinguished from biologic progress was the formation of associations of human beings or social groups. Blood relationship was perhaps the first bond of such organization. As the family grew into the clan and the clan into the tribe, a further sanction became necessary. For this purpose, it was essential to have a law which man must respect and an administrator of that law to whom men could pay deference. In order to fix and confirm an inherited, loose social organization, not equality before the law was needed, but obedience to the law.

War and religion established this obedience. War fostered the rapid reproduction of the race and implicit obedience to the accepted law. Religion furnished a supernatural sanction to social organization. Primitive religions, with their Phoenician Molochs and Aztec Huitzilopochlis, were incredibly cruel. They put upon the fixed law of the tribe a sanction so terrible that none dared ignore it. The punishments for nonconformity and infractions of the accepted ritual were most drastic and appalling in their severity. The individual who failed to show proper respect for any of the gods not only endangered his own life, but jeopardized the lives of his fellows. War and religion thoroughly cemented the "cake of custom," and thus

introduced solidarity into the social organization. But while rigidity of social structure has had its uses, it is only those nations which have broken through this "cake of custom" that have become progressive in the modern sense. This emancipation has occurred only in western nations, and in the last two hundred to three hundred years.

Under the conditions of modern civilization man has been compelled to take steps to annul the law of natural selection. It has been the only means by which the race could survive and still retain the vast social heritage that has been accumulating at a progressively increasing rate for generations. Upsetting any biologic process is a dangerous expedient. Nature thwarted exacts drastic penalties. The way of modern nations is beset with dangers, some of which are as old as social organizations, others distinctly new. The increasing complexity of group relationships has given rise to problems that demand the greatest intellectual capacity for their solution. Heredity is the only known biologic force capable of furnishing this social necessity of good brains. And yet modern society is wasting its supply of this irreplaceable material. Reservoirs of fresh germ-plasm, in the form of huge primitive populations with which to rejuvenate a decadent and declining race, do not exist in any abundance.

The mixture of totally unrelated human stocks almost invariably yields an inferior product. Miscegenation would be a cure worse than the disease. The "true-born Englishman" is, on the whole, a very desirable blend in spite of the bizarre, but still racially related elements of which, according to De Foe, he is composed.

These are the heroes that despise the Dutch,
And rail at new-come foreigners so much;
Forgetting that themselves are all derived
From the most scoundrel race that ever lived;
A horrid crowd of rambling thieves and drones
Who ransacked kingdoms and dispeopled towns;
The Pict, and painted Briton, treach'rous Scot,
By hunger, theft and rapine hither brought;

Norwegian pirates, buccaneering Danes,
Whose red-haired progeny everywhere remains;
Who, joined with Norman French, compound the breed
From whence your "true-born Englishmen" proceed.

Whatever else this "compounding of the breed" brought into England and thence to America, it did furnish a mass of excellent germ-plasm, a solid basis for a heredity with a high potential for social and intellectual capacity. That the best of this will ultimately be drained off and irrevocably lost as a result of the present differential birth-rate among the different social groups, leaving only the "scoundrel-race" portion, appears to be a reasonable certainty, unless mankind as an organized society takes some steps to prevent it. The human race may yet become "a penniless lass wi' a lang pedigree."

That artificial selection in the form of eugenics is the proper solution of the problem we have no absolute assurance, because there is no known standard by which to determine what heritable characters are best fitted for guaranteeing modern social progress. Perhaps any form of eugenics would be no worse than the present confused mixture of breeds and even of races. The criteria for fitness for survival are not the same under modern and under primitive conditions. Now that the human hand has been advanced from the lowly position of laborer to the more dignified status of superintendent of a tool, mere brute power and muscular strength are not so essential to survival as in earlier times.

Instead of being a slave to nature, modern man has discovered her secrets and has learned to make her power serve his individual and collective ends. Great

social and political development always requires a commensurate supply of productive energy. The only sources of such energy known to the ancient world were slaves and, to a less extent, domestic animals. They had no artificial forces to apply to production and transportation, and the only natural force effectively harnessed by them was that of the wind as applied to marine transportation. Their chief if not their sole means of meeting the demands of political and social expansion was by the extension of the system of slavery. Modern man, under similar conditions, increases the number and varieties of his machines.

By the development of language and by the invention of writing and printing, man has accumulated his present enormous and ever-increasing social and intellectual heritage. It is now possible for one generation to learn from the successes, failures and mistakes of previous generations. This lends interest, if it does not always add profit, to life and the mere process of living.

Man's discovery of means of emancipating himself from the tyranny of climate; his acquired ability to use the forces and resources of nature for his own purposes; his development of forms of social organization and of government that sanctions and encourages the unfolding of the latent potentialities of the individual members of society; his transformation of religion from a crushing social force based upon terror of the supernatural into a personal belief that does not insult his slowly developed power of reason—all these indicate that man has made social progress since he acquired a mind, as great, in its way, as the less readily disputed biologic progress of which man himself forms the capstone.

But is this alleged progress real or imaginary? Is it permanent or ephemeral? Pessimists insist that the idea of progress is an illusion, a tantalizing mirage on the desert of human existence. They assert that modern civilization will follow that of Babylonia, Egypt, Greece and other ancient peoples into a thoroughly deserved oblivion. The achievement of civilization has been a Sisyphean task. For the pessimist it will never be otherwise. Cogent reasons can be advanced for hoping that he is right. The uncertainty of constant striving is more enticing than the monotony of acquired perfection. It is useless to dispute this assertion of pessimism because neither side of the question is capable of such proof that the talismanic letters "Q. E. D." can be written after it.

Certain observations, however, are pertinent. In ancient times, nations rose to greatness by conquering and subjugating others. A civilization of great brilliance largely disappeared when the people which gave it origin became the oppressed subjects of a militarily stronger nation. As a result, great nations and their great civilizations were, in ancient times, generally solitary and segregated, and not contemporary or coexistent. "Fuit Ilium" became the epitaph of every conquered nation and its intrinsic civilization. Its fading inscriptions quickly became a sort of "gilded halo hovering round decay." At present, there are at least six great nations, or groups of related nations, each with its characteristic type of western civilization. Man long ago ceased to function effectively as an individual unit and became merged in the greater and more powerful and efficient group. This transformation of man from a troglodyte to a gregarious creature may have been an important factor in his survival as a species. It was certainly the basis of his developing what we call civilization and of his acquisition of the enormous heritage of social customs and intellectual capital that is handed on from genera-

tion to generation. Internationalism in some form may, indeed has already, become to the separate nation what society long since became for the individual man. It is not, therefore, a foregone conclusion that western civilization will follow its predecessors into the great maw of time and cease to be.

The outstanding feature of the past century has been the whirlwind progress of science. This has induced greater changes in any decade of this period than had occurred in any one or more millennia of past history. Change always requires adjustment. It is not the extent, but the rate of change that determines whether suitable adaptations can be instituted. This applies to social organizations as well as to individuals. Henry Adams found it necessary to reeducate himself three times in order to harmonize with his environment, completely altered by the general application of scientific discoveries and inventions. The public mind is still so polarized that its lines of force run in much the same direction as in prescientific days. Individual habits are difficult to change. But social customs, which are the habits of organized society, require generations for alteration. Human nature, made up of social customs and individual habits almost hopelessly enmeshed and entangled with the long thread of human heredity, has perhaps not been materially changed since the last glacial epoch. At best, civilization is little more than a mask with which to cover the ugly face of the savage inner man.

And yet man, composed as he is of a mixture of miscellaneous passions and instincts inherited from prehistoric and possibly from prehuman ancestry, has learned from science to build for himself mechanical devices wherewith to multiply his powers a thousand-fold. Much of his effort in this direction has been turned to the making of implements of destruction beside which Jove's thunderbolts were mere toys. The prospect of this partially tamed savage "running amuck in the full panoply of civilization" is frightful to contemplate. This Tubal Cain whom we call civilized man is a skilled "artificer in brass and iron," but he still "speaks as a child, understands as a child, thinks as a child." He acquired the knowledge with which to fashion for himself the powerful and dangerous instruments of modern science before he developed the judgment and wisdom to use them wholly for his own good. He has learned to outrun the horse and to outfly the eagle, but in the solution of the new problems these strange powers have brought, he progresses at the speed of the sluggish tortoise. He sends his thoughts around the world with the speed of light, while his thinking is still attuned to that of his forefathers, who were accustomed to learn of battles fought and won weeks after treaties of peace had been signed. He has invented machines by which he can, in a day, destroy a whole city, without attempting to curb those inherited instincts and acquired emotions that demand their employment. The astronomers have taught him that the great blue vault above him is not the under surface of the floor of heaven upon which rests the throne of an omnipotent God awaiting the opportunity to cast him into a burning hell whose chimneys are the earth's belching volcanoes. He is coming to believe that he lives in a universe devoid of both a physical heaven and a physical hell, without formulating for himself a sanction for his conduct to replace that of postmortem rewards and punishments formulated for him by his spiritual advisers. He enjoys the luxurious ease and physical comforts of modern civilization but is unwilling to exert his mind sufficiently to discover the means of averting the dangers which

threaten his social organization and even his race. When dangers become too imminent he is too willing "to grasp the skirts of happy chance" and to adopt some expedient which can only postpone the day of final catastrophe. Man is the earth's most arrant opportunist.

From him "hope still tells a flattering tale." He is loath to believe that the modern scientific equivalent of the ancient "gorgons. hydras and chimeras dire" still beset the path of the race. He hopes somehow to "invert the miracle of Circe." The unhappiness of the world, he believes, must in some way be banished and the misery alleviated. To further this end, man has invented the modern system of charity. This device, energized by sentiment and poorly lubricated with reason, has worked harm both socially and biologically that is hardly balanced by the good that it has done. The promiscuous and illogical giving of aid to the unfit and discontented has brought individual and social disaster since the Roman mobs were given free corn and free entertainment by their uneasy emperors. Rational charity is both desirable and necessary under modern social and economic conditions. But charity, born of vanity and nurtured on self-appropriation, is a curse both to him who gives and to him who receives. John Reed thus aptly described this type,

> And here's the rich man fidgeting beside us,
> Who tries to be Maecenas, and is Midas;
> And from his talk it presently appears
> That every Midas has an ass's ears.

Present social conditions, generated by the scientific discoveries and the resulting multitudinous inventions of the past century, have led to a dangerous over-specialization. Biologic over-specialization has frequently caused extinction of species. The fossil remains of many extinct animals show this phenomenon. The saber-toothed tiger, the mammoth, the gigantic saurians of Mesozoic times, all exhibited some form of this condition. A high degree of specialization may mean absolute dependence upon some peculiar condition of food supply, the elimination of which leads to the extinction of the species; or the over-development of some "useless dominant organ," such as huge tusks or antlers, violates the law of economy of growth and the species disappears.

Modern society is dangerously over-specialized in the distribution of population and in industry. Dangerously, because this set of new conditions is apparently irreversible, for human life has come to be dependent upon them. "The rise of great modern cities has been due to, first, the industrial revolution which made possible the growth of vast manufacturing centers; second, the rapid development of international trade, stimulated by recent inventions and by improvements in transportation; and third, the increase of population, which itself is an outcome of the new inventions and of the industrial revolution." Urban populations are not self-supporting. They are dependent for their food supply on an efficient system of transportation and for water upon an elaborate plexus of pumps and pipes. A partial breakdown of either would cause suffering; a complete failure would mean disaster.

Under the old system of production, the worker was a true craftsman; under the modern system, he is part of a machine. The modern system guarantees efficiency and vastly increases production, but "tends toward the standardization of mind and the elimination of intelligence." The older system yielded less product but developed personality. "They are happy men whose natures sort with their vocations," said Bacon. Men who will stand for eight hours a day and monotonously screw a nut on one particular bolt as pieces of machinery slowly pass in endless pro-

cession may be happy, but they will never make social progress.

The population of the world, increasing at a prodigious rate since the beginning of the industrial revolution, has not yet reached such magnitude that it can not be fairly easily supported by the modern methods of agriculture and transportation. The present number of people could not, however, be sustained by the methods of agriculture and the means of transportation of a century ago. Modern civilization is built largely upon a foundation of coal and iron. It can continue to exist only as long as its foundation endures or suitable substitutes found for the elements that compose it. The extinct civilizations of the past at least left man's natural resources intact. But the bacchanalian fervor with which the human race in its present state of obfuscated and pot-valiant civilization is now expending the earth's irreplaceable mineral wealth impels one to wonder what is to follow this period of debauch when the supply of inebriating drink has been exhausted.

All these gloomy observations lead to certain more fundamental considerations of this modern phenomenon called progress. Man has accomplished and gained much since he acquired a mind as a result of those biologic processes of variation and natural selection by which he developed his complex brain. Is he, like a drunken gambler with fate, to lose it all? He certainly holds the key to his own future. In the past he has advanced; he has improved himself; he has acquired a material and intellectual heritage that might well excite the envy of the dwellers on Olympus; he has formulated for himself and successfully executed designs on the trestle-board of life so ambitious that former generations would have considered them impossible of accomplishment except by superhuman aid. The universal wish for superhuman strength that was father to the thoughts which created Atlas, Hercules and other mythical giants of antiquity, modern man has realized by his invention of machines. The major part of these achievements has been consummated since he conceived the idea of progress.

Since its conception, the content of the idea has varied with the changes in the intellectual medium which it has bourgeoned. The earlier thinkers on this subject, Bacon, Descartes and others, considered only progress in knowledge; Hegel and Comte added a spiritual component; modern science has given it a materialistic element. Social and intellectual characteristics of the different periods have paralleled the variations in the content of the idea of progress. In the first period, Swift and Pope wrote biting unemotional satire; in the second, Victorian authors catered to prudery; in the third has come the literature of crude realism and a crude disillusionment. In the earlier periods, the fact of progress was widely accepted as established truth. At the present time its existence is seriously questioned even by those who admit its value as a stimulating idea.

Before this idea could become dynamic, man had to rid himself of the illusions of finality and perfectibility. All the Utopias have been peopled by beings who possessed those qualities which, in the conception of the author, constituted a perfect man. The ideal of Utopian progress is the achievement of a state of perfection. But progress considered as the attainment of a fixed stable good, as the performance of a definite sum which lessens by that much the total effort required to reach the ultimate goal, *is* an illusion.

Mankind, until this modern age, has been obsessed by the idea of finality. His place and fate were unalterably fixed

and no effort on his part could change them. He must not inquire too curiously into the forbidden secrets of the gods, nor attempt too persistently feats reserved only for the gods. The stories of the Garden of Eden, of Prometheus, of Icarus, indicate the attitude of apprehension assumed by the ancients toward the conquest of nature. Their gods were both jealous and prudent, for man has always been audacious.

> Man finds no feat too hard or high;
> Heaven is not safe from man's desire.
> Our rash designs move Jove to ire,
> He dares not lay his thunder by,

said Horace. But modern man no longer fears the gods. He is not frightened by Jove's thunder and would laugh at the petty shafts with which Apollo slew the children of poor Niobe. To the ancients there was a fixed order in the universe. Human progress to them would mean the breaking down of the limits with which man had been encompassed, and therefore unthinkably audacious and perilous. Modern man thinks of a fixed order in the universe as an expression of the immutability of the laws of nature. Within the limits of those laws he has assumed the right to use the forces and materials of nature in any way and to any extent he chooses in the furtherance of his own preconceived plans. He therefore presumes to violate the tree of knowledge and the sacred reaches of the upper air with impunity.

Human progress, as distinguished from biologic progress, has been defined as the development and economy of forces—force being anything that does or helps to do work. Such progress could only be achieved by rational beings. And yet relatively little of man's advancement has been the product of planned, intelligent guidance. Nevertheless, man has progressed; even though his progress has been extrinsic, that is, due to artificial changes in his environment including the increased store of transmitted experience, rather than intrinsic and due to changes in the nature of man himself. Perhaps, therefore, Professor Dewey is right when he insists that "till men give up the search for a general formula of progress they will not know where to look to find it."

It is useless to attempt to formulate an ideal of the future progress of the race. There are too many contingencies which can not be forecast. Man, as a race, has been and is resourceful. He has had curiosity, eagerness, love of action, endurance, hope, simply because these qualities are a part of his make-up, not because of his taking thought of them. The story of his past, read as a mere story, and his present propensities viewed too critically, are not especially promising. "History has been defined as a process of rebarbarization." Man has repeatedly lapsed into barbarism or something akin to barbarism. But somehow, each time this has happened, his innate hope and eager curiosity and love of action have stimulated him to rise to something better. This rehabilitation has not been inspired by an ideal of some unattainable infinite goal of good. It has been accomplished by the study of the needs and possibilities of the actual situation and by actions suited to those possibilities and needs.

The foundation of human progress is, and perhaps will always be, the nature of man himself, and this has apparently remained unchanged for at least many thousands of years. The material basis of that nature is in his complex brain which is the material theater of his versatile and active mind. With the apparent evolutional stabilization of the structure and functions of man's body, which determines and fundamentally influences his spiritual and intellectual activity, it does not appear likely that human nature will, in the future, un-

dergo any very deep-seated intrinsic change.

No attempt is made, therefore, to formulate any ideal of progress or to picture another Utopia. Progress, biological, social and perhaps spiritual, has been achieved. Further advance will be the result of the same factors which have been responsible for it in the past. Those factors are inherent in the nature of man himself. Such progress need not be uninterrupted and will not bring freedom from cares and worries and fears, for it will not mean the attainment of perfection. It may never mean happiness for the same reason. But it will afford the pleasure that goes with accomplishment and the elation that accompanies the stimulus of an unattainable goal.

The mental reaction to such a view will depend upon the individual attitude toward the possibilities of human kind. It will not satisfy one addicted to pessimism, for his thought of the future of the race is that of

> A sob, a silence, and a gasping spark;
> A word that, spoken, cannot be unsaid;
> A doom that, uttered, leaves the whole world dead;
> Ashes and smoke, and then the final dark.

Nor will it accord with the too buoyant and uncritical faith of the Pollyannas and Pippas, who hopefully reply to the jeremiads of pessimism.

> O, yet we hope that somehow good
> Will be the final goal of ill;
> To pangs of nature, sins of will,
> Defects of doubt and taints of blood.

This conception of progress places the responsibility for the future upon man himself, and yet furnishes a rational basis of hope for the future of the race. It supplies the stimulus of definitely fixing responsibility for that future. Man has been given his opportunity. Justly, he can ask no more.

THE FUTURE BALANCE OF LIFE[1]

By AUSTIN H. CLARK
SMITHSONIAN INSTITUTION

What is to be the future balance of the animal life upon the earth? Will man remain supreme, continuing to hold his own against his numerous competitors, or will the Age of Man give place to another age in which the human race shall play a minor rôle or perhaps wholly disappear?

In Mesozoic times the reptiles were the dominant living creatures of the earth, but their supremacy came to an abrupt end with the end of the Cretaceous. Why this occurred we do not know.

The Age of Reptiles was succeeded by an Age of Mammals, which culminated in the Pleistocene.

With the disappearance of the great hoofed animals, especially the grazing kinds like the wild cattle, the wild horses and the bison, extensive cultivation of the soil was possible, and man increased in numbers and in influence until now he reigns supreme.

The disappearance of the great herbivorous mammals was possibly partly due to man himself through his increasing skill in the manufacture and the use of weapons. But probably it was mostly due to causes still unknown, for in North America there is no evidence that man played any appreciable part in the extermination of the very numerous horses, the elephants, the mastodons, the various kinds of camels or the ground sloths.

What are the conditions at the present time? The world to-day is dominated by four different types of life which are distinguished from all other types of life by having certain characters in common. These common characters are (1) independence of the temperature and the humidity of their environment, and (2) exceptional ability to travel.

First, we have man. Man in his bodily structure is a mammal. But, excepting anatomically, it is not possible to consider man in the same light as the other mammals, even the more or less man-like apes. Man's use of clothing and of fire render him independent of the temperature of the locality in which he lives, while his use of beasts of burden and of tools give him a power and a radius of action quite unique.

Second, we have the mammals, formerly predominant but now scarcely a serious factor except for those few, like rats and mice and the domesticated animals, that live as man's associates. Mammals, excepting for a very few that live within the tropics, have an outer coat of hair or a covering of fat which insulates them from the changes in the temperature of the air or water. Their body temperature is high and is maintained at a constant level, except in the hibernating types like some bears and mice and squirrels which become torpid in cold weather, and in the egg-laying types. Mammals are all large, and some are very large. They are all active, and all show great ability to travel.

Third, we have the birds, now, like the mammals, much less numerous than they used to be. All birds have feathers which, like the hair of mammals and the clothes of man, serve to hold an insulat-

[1] The illustrations are through the courtesy of the Bureau of Entomology, Department of Agriculture.

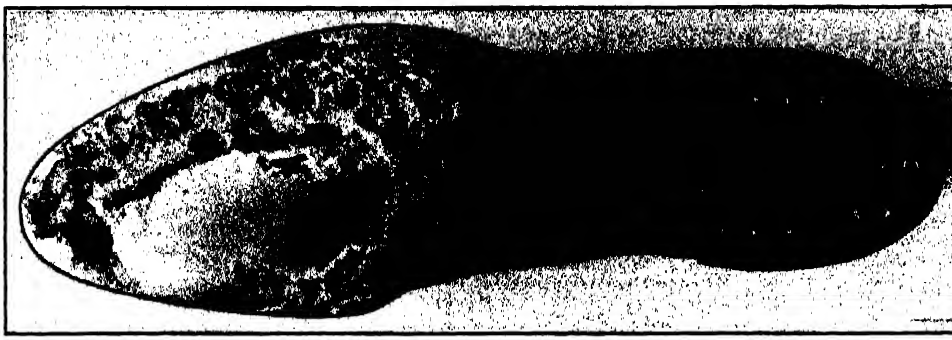


FIG. 1. DAMAGE DONE BY WHITE ANTS OR TERMITES TO A SHOE STORED ON INFESTED WOODWORK IN A BUILDING ON FIFTH AVENUE, NEW YORK

ing layer of air between their heated bodies and the air through which they move. The body temperatures of birds are high, and like those of mammals are maintained at a constant level. There are no birds that hibernate as some mammals do. The power of flight gives birds (and bats) a very great advantage in getting from place to place. But this advantage is offset by the necessary lightness of their structure as a whole and the uselessness, except for flight, of the first pair of limbs. The flightless birds are of three different types. The penguins and the flightless auks have their wings modified into effective fins by means of which they swim. The flightless cormorants, like the other cormorants, swim almost wholly with their feet, as did the flightless water birds of the Cretaceous seas. The flightless land birds, whether rails, pigeons, kiwis or ostrich-like types, have powerful legs and small and useless wings.

Fourth, we have the insects. The body temperature of insects is not appreciably different from that of their surroundings. But insects can adapt

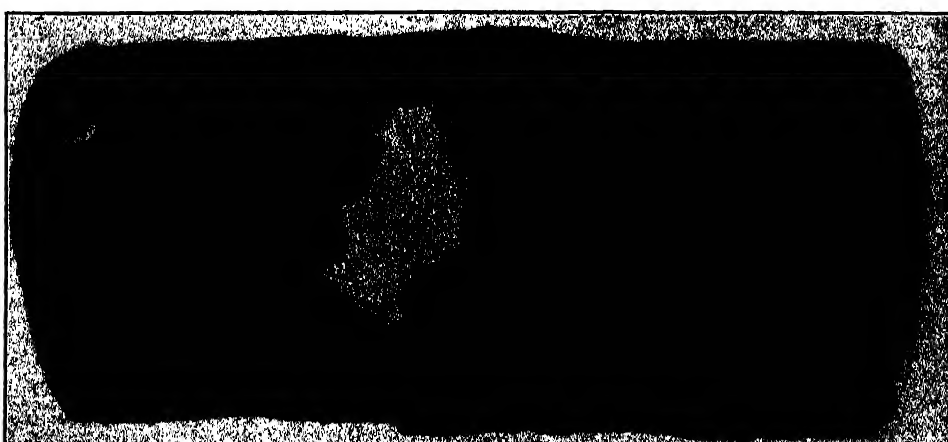


FIG. 2. TYPICAL TERMITE INJURY TO LEAD SHEATHED CABLE
THIS TYPE OF DESTRUCTION OCCURS THROUGHOUT THE WARMER REGIONS OF THE WORLD, INCLUDING THE SOUTHERN UNITED STATES.

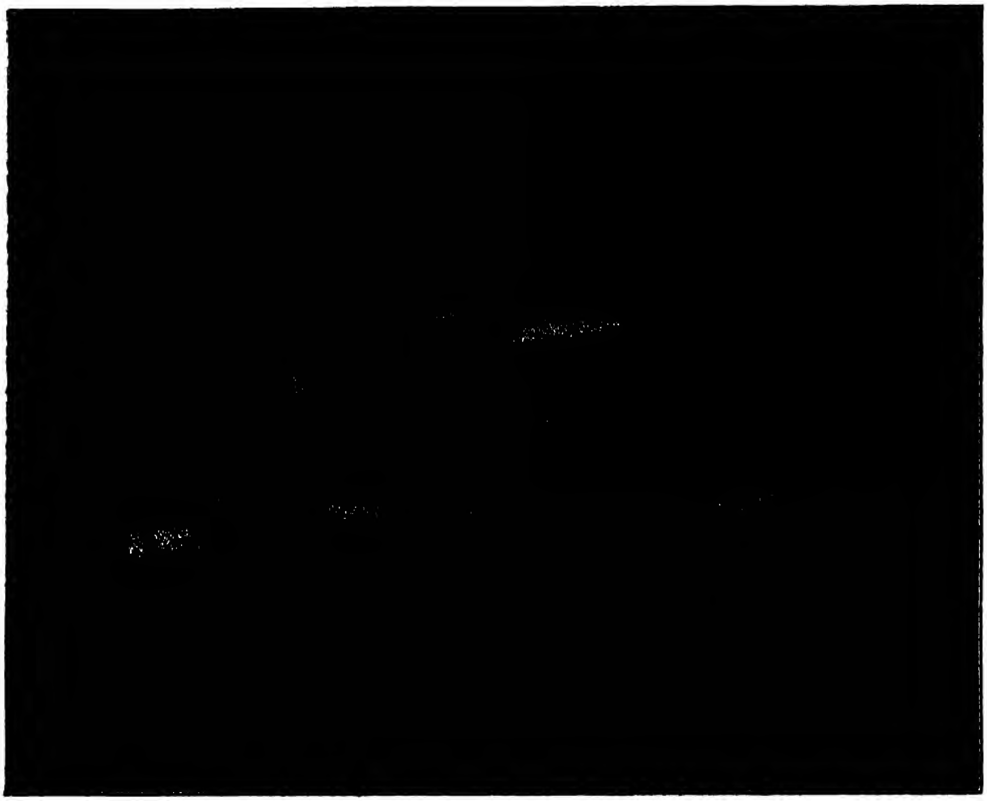


FIG. 3. PAPER DESTROYED BY TERMITES
THIS PAPER WAS STORED IN AN INFESTED BUILDING IN BALTIMORE, MD.

themselves to changing temperatures quite as well as mammals or as birds, though in a different way. They simply become inert and torpid, some if it gets too hot, others if it gets too cold, and not a few at both extremes. Nearly all of them are when adults, and mostly all their lives, protected from a loss of moisture by a tough impervious covering. Most insects when adult can fly, and many can cover enormous distances. The insects are all small, but this very fact gives them a great advantage not possessed by the mammals, birds or man. I am informed by Mr. René Bache that an average man is the equivalent in weight of 3,760,000 house-flies. This means that the ability of the common house-fly to survive under adverse conditions is 3,760,000 times as great as that of man.

This leads to interesting speculation as to what is to be the future of the world.

The mammals have ceased to dominate the earth. The large formidable vegetarian types, as has been explained, have given way to man. There seems to be no chance of their return.

Birds, though efficient in their way, were never serious competitors of the reptiles, or the mammals, or of man. Birds have persisted through their ability to escape from danger, not to overcome it, or to dominate the other creatures that live with them.

This leaves the insects as the chief competitors of man. In many ways

their activities run quite parallel to his. Strange as it may seem, the activities of the insects are more like those of man than the activities of either are like those of birds and mammals.

Some insects keep others as domestic animals, and in a few cases the latter would have disappeared but for the care taken of them by their masters. Thus the ants carefully care for and protect various kinds of aphids, jassids and membracids, as well as the caterpillars of certain lycænid butterflies for the sake of the honey-like secretions they produce. Their relation to these various insects is much like ours to cows. Usually the ants merely attend these as they feed upon the plants, but sometimes they build elaborate structures over them, like stables. Some of the aphids they carry to safety under ground in winter, and some of the caterpillars they herd in their own nests in the daytime, driving them out at night to feed and home again at dawn, treating them therefore much as we do cows. Indeed, certain ants of southern Asia and of Africa force some kinds of caterpillars to make the transformation into pupæ within their own nests deep underground, thus carefully protecting them from the time they leave the egg until they become butterflies and fly away.

Some insects have learned the use of tools, like the spinning ants, which use their own grubs in much the same way that we do thread and needle, and those caterpillar wasps that use a little pebble or a stick to smooth the earth down over a buried caterpillar.

A few insects use narcotics to render their victims helpless much in the same manner as do certain individuals of our own kind. For instance, there is a curious bug in Java which feeds on ants. When an ant approaches it rises up, exposing some long hairs on the under side which are wet with a secretion from some special glands. The ant greedily licks off this substance, which, however, is intoxicating. When the ant has had enough to make it "groggy" the bug

FIG. 4. A TIMBER DESTROYED BY TERMITES

FROM A BUILDING IN THE SOUTHERN UNITED STATES.

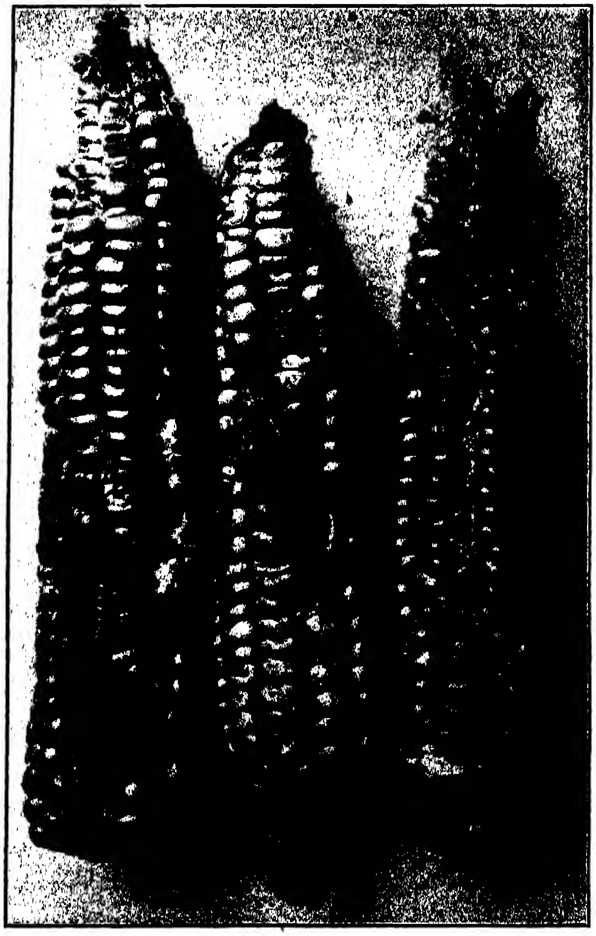


FIG. 5. THREE EARS OF FLINT CORN ATTACKED BY THE EUROPEAN CORN-BORER.

with its sharp beak stabs it suddenly through the neck and sucks its juices out.

Many ants practice an elaborate form of agriculture, growing certain types of fungi with as much skill as we show in growing our own crops.

The paper and the other kinds of nests of wasps, and the wax, mud and other cells of wasps and bees show an ability to use a wide range of materials, some of which are not found in nature but are produced by them themselves by chemical alteration of substances they gather.

The pitfalls of ant-lions and the snares of the grubs of fungus-gnats and spiders are most extraordinary structures. The spiders, especially in the construction of their numerous types of webs, of their varied types of burrows, sometimes with a strong hinged lid, and of their turrets, as well as in their flight, show an engineering knowledge which in its way is quite exhaustive.

In two entirely different groups of in-

sects, the neuropteroid termites and the hymenopterous ants, bees and wasps, there are found most complicated social systems, superficially much like, though fundamentally wholly different from the human.

Very many insects of a multitude of different kinds have learned to clothe themselves. Large numbers, as for instance caddis worms and clothes moths, do this for protection in their larval stages. But many more when entering the pupal stage spin a cocoon of silk or of a felt of silk and hair or of a mixture of silk and other substances which is sometimes waterproofed to guard against the loss of moisture.

Many insects, among the solitary as well as among the social kinds, have a very definite conception of private property and their rights thereto.

One commonly hears it said that among the insects all these attributes are matters of instinct, which is quite inflexible, and not of reason, and therefore that an insect can not change its habits. But this is not quite true. Many insects have the ability to change both form and habits if faced with new conditions.

Among the birds we find only the bowers of the bower-birds, ornamented nests of various sorts, the communal nests of certain weaver-birds and parrots, the complicated nests of other weaver-birds and "hang-nests," the glutinous nests of certain swifts, and a few other types of nests to offset the multitudes of far more elaborate structures built by the insects. Among the mammals we find little of a comparable nature, and what there is is almost entirely confined to rodents, such as the beaver, musk-rat, trader-rat, etc.

In the distant prehistoric past man made use of various mammals which he

FIG. 6. ORCHARD TREES WHICH HAVE BEEN KILLED BY THE SAN JOSE SCALE.

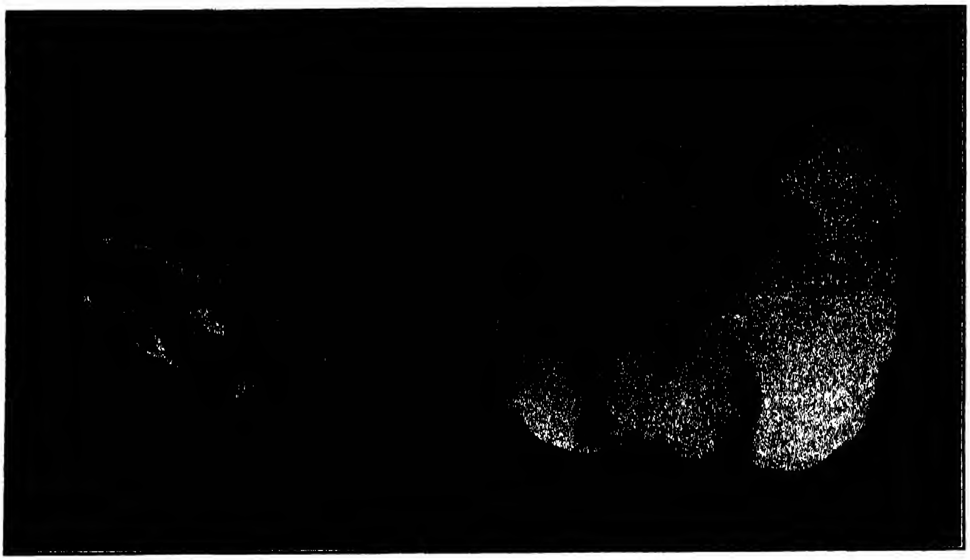


FIG. 7. THE COTTON BOLL
THE BOLL ON THE RIGHT IS NORMAL; THAT ON THE LEFT HAS BEEN ATTACKED BY THE PINK BOLL-WORM.

FIG. 8. A BEAN LEAF
WHICH HAS BEEN SKELETONIZED BY THE MEXICAN BEAN BEETLE.

domesticated to overcome the others. He did this, however, with no definite purpose and with no definite idea of what the result would be. At the present time the insects are making similar use of man. The recent vast improvement in the means of transportation, by steamer, train and automobile, is being utilized extensively by insects. By this means they get from place to place and from one country to another, passing easily over barriers hitherto insuperable for them. Also the vast improvement in our agricultural methods whereby large areas are planted with a single crop facilitates the increase of destructive forms.

As matters stand to-day, mankind exists in his present state by virtue of the fact that he has displaced the large grass-feeding mammals and thereby is enabled to practice agriculture on a

colossal scale. But the limit of expansion on this basis soon will be reached.

We now are in the midst of the mechanical phase of the Age of Man, and we have no serious competitors except the insects. By an uncomfortable coincidence, much that we do to help ourselves also helps the insects.

Not many generations hence we shall have reached the saturation point along the present lines. Our future expansion then will depend on our ability to offset the increase in the human population of the world by the displacement of its equivalent in insects.

What will the future bring? Will man continue still to hold his own, or will the Age of Man be followed by the Age of Insects?

FISHES THAT LIVE IN THE MOUTHS OR GILL CAVITIES OF OTHER FISHES[1]

By E. W. GUDGER

ASSOCIATE IN ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

It is a fact well known to ichthyologists that the hagfishes, *Myxine* and *Bdellostoma*, and various lamprey eels, all members of the class Cyclostomata or round-mouthed fishes, have parasitic habits. Indeed, the American Museum has an exhibit, designed and the installation supervised by Dr. Bashford Dean, showing a river lamprey (*Lampetra fluviatilis*) parasitic on a catfish. Sucking fast to its host, this parasite by means of the teeth set inside the circular rim of its mouth, frets away and eats the flesh of its host and drinks its blood. On the other hand, the hagfishes or slime eels, bore their way into the bodies of their hosts, devour the flesh and internal organs, often leaving nothing but "skin and bones."

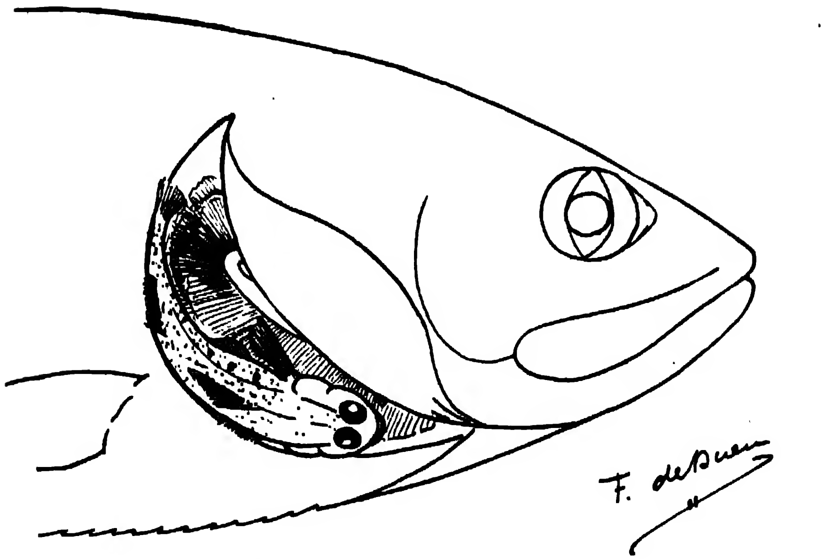
Still less well known is the fact that a little catfish in South America, bearing the significant name of *Stegophilus insidiosus* (the "insidious cover-lover") lives in the gill cavities of his huge kinsman *Platystoma*. At first it was thought that the little siluroids were the young of the big catfish carried in his mouth until hatched and able to care for themselves (a very extensive practice among these fishes). Then it was presumed that they were messmates of their kinsman, living on small organisms drawn into his mouth in his respiration. But now they are known to be parasites living among the gills of their host and rasping with their sharp teeth and spines through the soft tissues of the gills and drinking his blood. Other fishes of the same group are known to practice the same habits.

These are cases of true parasitism—the fish lives on the flesh and blood of its host—while the cases now to be considered are cases of commensalism, where the two fishes feed at the same table, or of symbiosis, where the two fishes merely live together—the weaker for protection by the stronger. The most widespread but relatively little known case of this latter phenomenon, until the publication of my recent article in *Natural History*, is the habit of various members of the family Echeneididæ, the sucking fishes, of entering the mouths and gill cavities of sharks and rays and of large bony fishes like the swordfish (*Histiophorus*), the sailfish (*Tetrapturus*), the sunfish (*Mola*) and others. This paper aroused considerable interest and various accounts of this habit and several actual specimens of the little fishes have since come in to me. This is a case of commensalism, where the two fishes live in amity—the smaller gaining protection and possibly feeding on the scraps let fall by its protector.

Now, however, we have the still more remarkable case of bony fishes other than Echeneids (sucking fishes) living as commensals or symbionts in the mouth cavities of other Teleostean fishes. The sucking fishes are more or less dependents, but the fishes now to be considered are apparently free-livers. How they gather food is not very clear, but all the known facts follow.

The principal account is from the ob-

[1] Gudger, E. W. "An Odd Place of Refuge: The Habit of the Shark Sucker, *Echeneis* or *Remora*, of taking Refuge in the Gill Chamber or Mouth Cavity of its Host." *Natural History*, 1922, **22**, pp. 243-249, fig.



servations of Dr. Fernando de Buen, chief of the section of biology in the Instituto Español de Oceanografia, Madrid. In checking up recently the bulletin of the Spanish natural history society for titles for our continuation classified card catalogue of ichthyological literature, I chanced upon his interesting illustrated article quoted below. When I wrote Dr. de Buen asking permission to utilize his data and reproduce his figure, he courteously gave permission for the use of the one and sent the original of the other. His account reads as follows:[2]

While studying the Clupeidæ that Professor Lozano possesses in his laboratory at the Madrid Museum, I had the good fortune to find one of them lodging a small *Gobius* in the gill cavity. The specimen was captured at Melilla (Aug., 1912) during the expedition directed by my father in the north of Africa.

From the position in which it was found and for other reasons which are given later I can not believe that the *Gobius* caught in the nets and mixed with a profusion of *Alosa* will introduce itself into the gill chamber of one of these fishes casually. The species identified as *Gobius pictus* Malm has never been cited off the coasts of Spain nor in Northern Africa, but lives in the depths of the Northern European seas, and one may believe with more foundation that it was transported to the south during the migrations of the Clupeidæ. Moreover, the *Gobius* presents very clear phenomena of adaptation; the first and second dorsals have the first spine growing on the back and this is prevented from being raised by a membrane which fastens it and runs on the same side outside of the median line; this adaptation proves to us that the *Gobius* has been carried for a long time in the gill chamber of the *Alosa*. On the other hand, commensalism between fishes is very rare; but I know of an analogous case (Van Beneden, 1883) where Risso says that he observed at Nice a species of the family Murænidæ lodging in the gill cavity of a *Lophius piscatorius* L. The *Gobius*, on account of its small size and the power of using the ventral fins as a sucker (*Gobius pictus* has this highly developed), possesses qualities very favorable to commensal life.

From the outside of the *Alosa* nothing abnormal is seen; the gill flap is perfectly adapted and completely hides the fish which it covers. Lifting the flap, the *Gobius* is seen resting on the shoulder girdle; its head is placed in the broadest part, and its body extends upwards, making place for itself at the end of the gills. The body of the *Gobius* is compressed and sloping, a transverse section giving approximately a rhomboid figure.

[2] Buen, Fernando de, "Sobre la Presencia y Caracterización de un *Gobius* de los Mares del Norte Comensal de una *Alosa vulgaris* Cuv. Val." Boletin Real Sociedad Española Historia Natural. Madrid, 1916, Vol. 16, pp. 146–147, fig.

Apart from the modifications that we see in the dorsal, the other fins adapt themselves to the surfaces that surround them. The ventral, perfectly extended, appears to be adhering to the gills of the *Alosa*. One of the pectorals rests on the shoulder girdle and is folded outside; the other pectoral is folded simply that it may not come in contact with the gill flap. The anal inclined outwards rests on the shoulder girdle.

De Buen positively identifies his specimen as *Gobius pictus* of Smitt's "Scandinavian Fishes" (1892). The length of the *Alosa*, the host fish, to the base of the caudal fin was 213 mm (about 8.5 inches); of the *Gobius*, 36.5 mm (about 1.5 inches).

Señor de Buen's citation from Van Beneden is correct, since the latter does cite Risso. Careful examination of Risso's work on the fishes of the gulf of Nice[8] shows Van Beneden in turn to have been correct in his citation. On page 171 Risso in speaking of the "baudroies de la Méditerranée" says: ". . . le sac de leurs ouïes sert quelquefois de repaire à la apterichte oculé" ("the sac of their gills serves sometimes for a haunt or hiding place for *Apterichtus oculatus*"). This name is apparently a synonym for the Murænoid fish *Sphagebranchus oculatus* of Risso, but under this latter fish Risso does not refer to such a habit. However, referring to *Sphagebranchus bimaculatus*, he says (p. 196): "One often encounters it in the cavity of the branchial orifice of the great rays." This in turn apparently refers to the giant rays of the genus *Cephaloptera* (Manta), but reference to Risso's account of these rays reveals nothing.

It is greatly to be regretted that Risso does not give us more details concerning these interesting habits and adaptations. It is not difficult to understand how fishes like *Echeneis* or *Gobius*, which have adhesive disks made of transformed fins, by holding fast can avoid being swept into the stomachs of their hosts, but how eels can become mouth and gill symbionts and avoid that fate is not so easy to realize. However, as my old teacher, Professor W. K. Brooks, used to say, "It is not safe to say that a thing does not exist merely because we have never seen it."

[8] Risso, A., "Histoire Naturelle des Poissons de la Méditerranée qui Fréquentent les Côtes des Alpes Maritimes et qui Vivent dans le Golfe de Nice" (In his "Histoire Naturelle . . . de l'Europe Méridionale," etc. Paris, 1826, pp. 171 and 196).

THOMAS MOFFETT, ELIZABETHAN PHYSICIAN AND ENTOMOLOGIST

By HARRY B. WEISS

NEW BRUNSWICK, NEW JERSEY

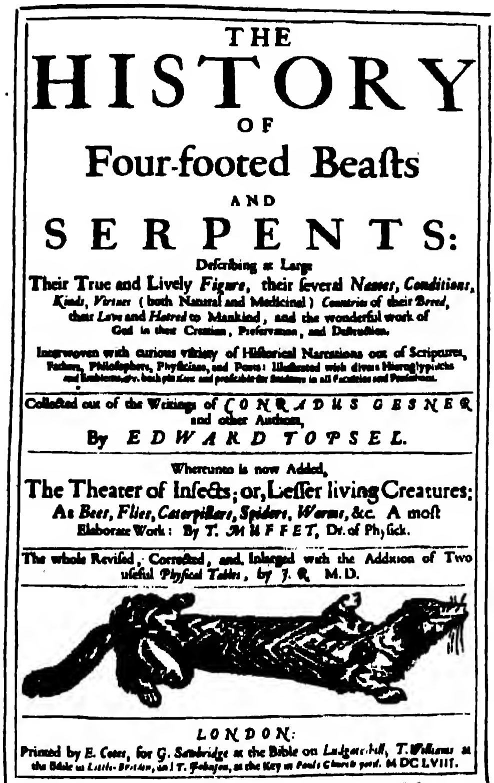
WHILE clever, sagacious, vain, kaleidoscopic Queen Elizabeth, who was alternately rough, blasphemous and hard, and silly, flattery-loving and ostentatious, and whose "endocrine balance" may have been abnormal, as MacLaurin suggests, was juggling suitors and giving England a stable government, there lived and flourished "a notable ornament to the company of Physicians, a man of the more polite and solid learning, and well experienced in most Sciences," named Thomas Moffett.

Of Scottish descent, born in 1553, in all likelihood in the parish of St. Leonard's, Shoreditch, Moffett's life paralleled the reign of Elizabeth. His father, Thomas Moffett, was a haberdasher of London, and his mother was Alice Ashley, of Kent.

For his early education Thomas was sent to one of the few good schools that existed during Elizabethan times, the Merchant Taylors' School, of which Richard Mulcaster, a notable schoolman, was headmaster for twenty-five years. Here his studies undoubtedly included drawing and music, of which Mulcaster was a strong advocate. After five years in this school, he matriculated in May, 1569, as a pensioner of Trinity College, Cambridge. He was then sixteen years old, and this was about the usual age prescribed by the university regulations for entering college. Seven years were necessary for the degree of master of arts, and one could then proceed to degrees in theology, medicine and law. However, by the payment of money or upon suitable approval from the right persons, noblemen and influential students frequently got their masters' degrees in less time.

In October, 1572, he went to Caius College, where he graduated B.A. While pursuing the classics he also studied medicine under Thomas Lorkin and John Caius, both physicians of note, and hobnobbed with Timothy Bright, Thomas Penny and Peter Turner. Timothy Bright later became quite distinguished as a physician, but is probably remembered now if at all in connection with his invention of modern shorthand, as set forth in his work: "Characterie. An Arte of shorte, swifte, and secret writing by character. Inuented by Timothe Bright. Doctor of Physicke." (London 1588.) Thomas Penny, in addition to being a physician, was also a botanist and entomologist and assisted Conrad Gesner, the Swiss naturalist, physician and voluminous writer on various subjects, famous for his "Historia Animalium," in which he intended to describe every known animal.

Moffett, deciding to graduate M.A., from Trinity College in 1576, was expelled from Caius by Thomas Legge, the master who later, about 1581, was apparently committed to the fleet because of his disdainful treatment of certain letters from the queen, relating probably to his support of north-country Romanists in his college. The fellows made this a charge against him, supplementing it with having expelled Moffett without their consent, with having misappropri-



THE
HISTORY
OF
Four-footed Beasts
AND
SERPENTS:
Describing at Large
Their True and Lively *Figure*, their several *Names*, *Conditions*, *Kinds*, *Virtues* (both Natural and Medicinal) *Countries of their Breed*, their *Love* and *Hatred* to Mankind, and the wonderful work of God in their Creation, Preservation, and Destruction.

Interwoven with curious variety of Historical Narrations out of Scriptures, Fathers, Philosophers, Physicians, and Poets: Illustrated with divers Hieroglyphicks [illegible]

Collected out of the Writings of *CONRADUS GESNER* and other Authors,
By *EDWARD TOPSEL.*

Whereunto is now Added,
The Theater of Insects; or, Lesser living Creatures:
As *Bees, Flies, Caterpillars, Spiders, Worms*, &c. A most Elaborate Work: By *T. MUFFET*, Dr. of Physick.

The whole Revised, Corrected, and Inlarged with the Addition of Two useful *Physical Tables*, by *J. R.* M.D.

LONDON:
Printed by E. Cotes, for G. Sawbridge at the Bible on *Ludgate-hill*, *T. Williams* at the Bible in *Little-Britain*, and *T. Johnson*, at the Key in *Pauls Church-yard*. MDCLVIII.

Title page of Topsel's "History of Four-footed Beasts and Serpents" to which Moffett's "Theater of Insects" was appended

ated college funds and with "continuall and expressive loud singinge and noyse of organs," which disturbed the students. All of which charges were settled.

Upon leaving Cambridge, Moffett traveled abroad. At Basle he attended the lectures of Theodore Zwinger and Felix Plater, both physicians, and in 1578 received the degree of M.D. and published two collections of his medical theses. The next year he visited Italy and Spain, where he studied silkworm culture and various insect activities. Twenty years later he published some of his observations in the form of a poem entitled: "The Silkwormes and their Flies; Lively described in verse, by T. M. a Countrie Farmar, and an Apprentice in Physicke. For the great benefit and enriching of England," (London 1599). In July, 1580, he was at Nuremberg, and often at Frankfort between October, 1580, and the spring of 1582. He married in London, at St. Mary Cole Church, Jane Wheeler, by a license dated December 23, 1580. In 1582 he returned to Cambridge and was incorporated M.D. In July, 1582, he visited Elsinore with Peregrine Bertie, Lord Willoughby, who clothed King Frederick, of Denmark, with the Order of the Garter. While there he attended court dinners that lasted seven and eight hours and met Peter Severinus and Tycho Brahe, the latter being the distinguished Danish astronomer, who, having lost part of his nose in a düel, replaced the missing tissue with gold, so cunningly colored and fitted that few could detect it, and who incurred the disgust of his fellow nobles by marrying a peasant girl, this being even more disgraceful than studying astronomy.

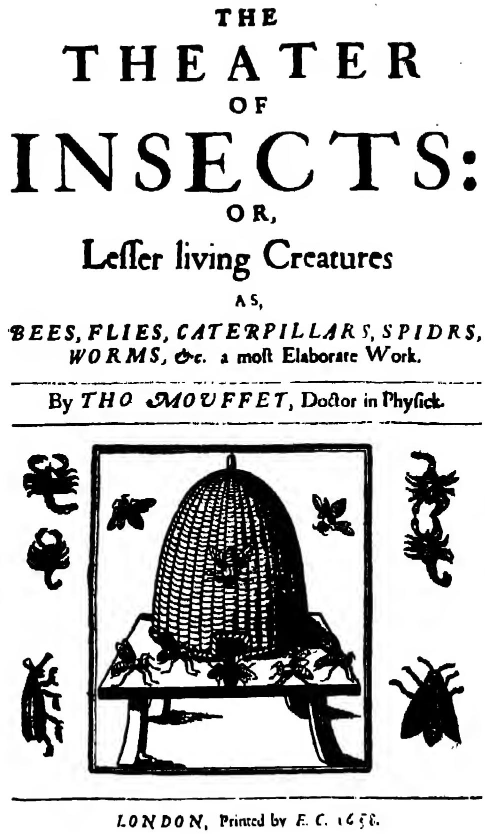
Moffett apparently liked to travel, in spite of the inconveniences and perils of the time. In England, littlo traveling was done for pleasure. Roads as we know them did not exist. They just happened, and moreover were infested by highwaymen, tramps, tinkers, jugglers, vagrants and beggars with filthy rags and running sores manufactured by the application of arsenic, unslaked lime or other corrosives. Linen was snitched from hedges, and other forms of thievery flourished even as they do now. Inns were numerous, but many of the servants were thievish.

At Frankfort in 1584, he published an elaborate commentary of his medical views written in a style similar to that of Erasmus's "Colloquia." The title is "De Jure et Præstantia Chemicorum Medicamentorum." With this he printed four letters addressed to Phila-

lethes Germanus and one to Endymion Luddipolensis, the five being dated from London between February and April, 1584. The work received some notice abroad and attention in Zetner's "Theatrum Chemicum" published at Strassburg in 1613. All Moffett's medical books appear to have been published at Frankfort, then the center of the book trade in Germany and seat of the semiannual book fair to which publishers took their samples.

While in Europe, Moffett became infected with the Paracelsian doctrine of medicine, and when he established himself in England he and John Hester, translator of medical books and distiller, or, as he styled himself, "practitioner in the Spagericall Arte," at Paul's Wharf, became the chief exponents and defenders of the Paracelsian system.

During the beginning of the sixteenth century, the Galenists, with their complex and polypharmous vegetable prescriptions, were the most progressive branch of the medical profession and with the followers of Hippocrates, master of detail and founder of medicine as a science, they had no serious disagreement. From the ranks of the Galenists sprang the Chymists, with their empirical practices and additions to the materia medica and pharmacopeia, which sect flourished during the latter part of the century. Philippus Aureolus Theophrastus Bombastes von Hohenheim or Paracelsus, whose system attracted Moffett, was a widely traveled German physician and chemist, whose real or imitation cures and large practice attracted patients of quality from all parts of Europe. Insolent, inflated and bellicose, he publicly burned Galen's works at Basle and disregarded custom by lecturing in German instead of Latin. He contributed opium, mercury, sulphur, salt arsenic, iron, etc., to materia medica, was killed by being thrown out of a window by a colleague during a heated


THE
THEATER
OF
INSECTS:
OR,
Lesser living Creatures
AS,
BEES, FLIES, CATERPILLARS, SPIDRS, WORMS, &c. a most Elaborate Work.

By THO MOUFFET, Doctor in Physick.

LONDON, Printed by E. C. 1658.

TITLE PAGE OF MOFFETT'S "THEATER OF INSECTS"

argument, and is generally characterized as the "greatest charlatan and mountebank that ever acquired celebrity in the profession."

Moffett apparently was not completely won over to the Paracelsian system, for in 1588 he published again in Frankfort a digest of Hippocrates entitled, "Nosomantica Hippocratea sive Hippocratis Prognostica cuncta ex omnibus ipsius scriptis methodice digesta." By this time he had secured a good practice, first in Ipswich and later in London. He was admitted as a candidate of the College of Physicians on December 22, 1585, and as a fellow and censor in 1588.


CHAP. II. Of lesser living Creatures. 939

A PAGE OF MOFFETT'S BOOK, DEVOTED TO "FLIES"

London at this time was for the most part a network of badly paved lanes made tenebrous by the overhanging fronts of houses and malodorous by the householders, who deposited their garbage and refuse in the gutters. Mud and filth prevailed in many streets. Coaches and carts rattled by, regardless of whom they splashed after a rain, and often blocked the streets, while their riders shopped and haggled over prices. Dekker wrote:

> In every street, carts and Coaches make such a thundring as if the world ranne vpon wheeles; at evrie corner, men, women, and children meete in such shoales, that posts are sette up of purpose to strengthen the houses, least with iustling one another they should shoulder them downe. Besides, hammers are beating in one place. Tubs hooping in another, Pots clincking in a third, water-tankards running at tilt in a fourth; heere are Porters sweating vnder burdens, there Marchants-men bearing bags of money, Chapmen (as if they were at Leape-frog) skippe out of one shop into another; Tradesmen (as if they were dancing Galliards) are lusty at legges and never stand still; all are as busie as countrie Atturneyes at an Assises.

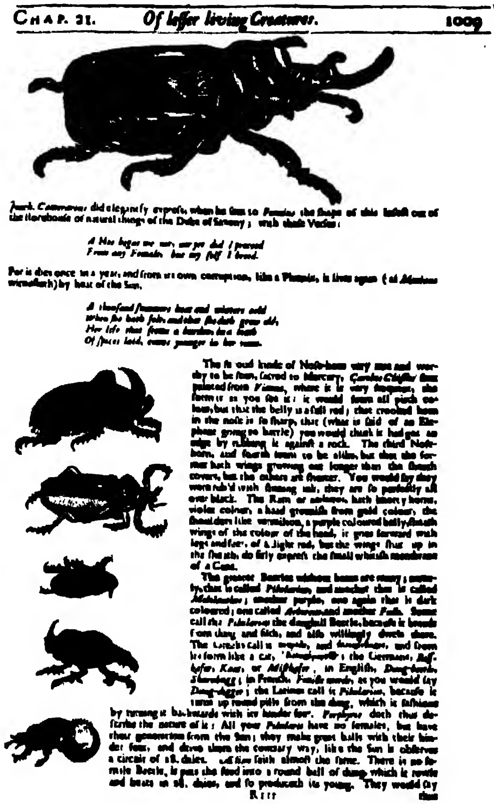
The main thoroughfare was the Thames, which every one used in preference to the narrow, dirty streets. Ferries ran to and from various points, and all kinds of craft sailed the river. And there was London Bridge with its houses and shops and covered way, and the tower guarding the middle draw ornamented by poles on which were stuck the rotting heads of traitors.

Some of Moffett's patients were quite distinguished. In 1590 he attended Sir Francis Walsingham, fanatical Puritan who looked after Elizabeth's designs against the Jesuits and was one of her most capable statesmen. Early in his practice he attended Lady Penruddock and Sir Thomas and Edmund Knyvet. In July, 1586, Drs. Penny and Moffett attended Anne Seymour, duchess of Somerset, and attested her will. In 1591 he was appointed physician to the forces operating in Normandy under the Earl of Essex. After his return to London he frequently attended court and was patronized by Henry Herbert, second earl of Pembroke. Mary Herbert, the earl's wife, patroness of men of letters and poets, captivated by his culture, persuaded him to live in Wiltshire at her home. The earl gave him the near-by manor-house of Bulbridge for a residence, and the latter part of his life was spent at or near Wilton, as the earl's pensioner. As a result of the earl's influence he was also elected M.P., for Wilton in 1597. While at court he became acquainted with Sir Francis Drake, chief

naval worthy of the time, whose piratical enterprises against the colonies of Spain won the approval of Elizabeth.

Moffett's wife died while they were living at Wilton and was buried there on April 18, 1600. He married again a widow named Catherine Brown, but did not live long, dying June 5, 1604. He was buried in Wilton Church. Moffett's second wife survived him, and to her four children by her first husband Moffett, in addition to other bequests, willed his musical instruments, including a pair of virginals. Moffett's own daughter Patience is mentioned in the will, and his brothers William and Thomas were made overseers. When Moffett's widow died in 1626 she left to Patience a portrait of Moffett and a book "in his writing."

Moffett was the author of two posthumous works. In 1590 he had finished a book on the natural history of insects, which represented in part compilations from the works of Edward Wotton and Conrad Gesner and from papers left to him by Thomas Penny, botanist, entomologist, friend of Gesner and prebendary of St. Paul's. Moffett, in the preface of his book, speaks of his indebtedness to these and other persons, including Peter Turner, whose letters came also into Moffett's possession. The plates for the illustrations appear to have been Turner's. Moffett was alternately encouraged and discouraged as he wrote his "history." His friends deterred him for a while because they thought insects insignificant and Moffett wasting his time by shaping the work of others. He persisted, however, in going ahead, adding more than 150 illustrations unknown to Gesner and Penny, correcting the language and omitting more than a thousand "tautologies, trivial matters and things unseasonably spoken," because, as he said, of "the squemish stomachs of men of this nauseating age."


CHAP. 21. *Of lesser living Creatures.* 1009

A PAGE OF MOFFETT'S BOOK, DEVOTED TO "BEETLES"

After its completion, he obtained permission for its publication at the Hague on May 24, 1590, and dedicated it to the queen. Delays followed, however, and after the queen's death it was rededicated to James I. After Moffett's death the manuscript found its way to the hands of Darnell, Moffett's apothecary, who sold it to Sir Theodore Mayerne. Mayerne was a French physician who defended the use of chemical remedies. He became unpopular in France and went to London in 1611, where he established a large practice. Mayerne kept the manuscript for some years, due to the high cost of printing, and finally published it in London in 1634 with a

dedication to Sir William Paddy, another London physician, the title of the folio being, "Insectorum sive Minimorum Animalium Theatrum . . . ad vivum expressis Iconibus super quingentis illustratum." In 1658 it appeared in English, under the title "The Theater of Insects, or lesser living Creatures," having been translated by John Rowland, M.D., and appended with plates to Topsel's "History of Four-footed Beasts and Serpents," "The whole Revised, Corrected, and Inlarged with the Addition of Two useful Physical Tables, by J. R. M. D."

Moffett's *magnum opus,* said to be the first zoological work printed in Britain, is divided into two books, the first consisting of twenty-nine chapters and the second of forty-two. Seven chapters of Book I are devoted to bees, and the remaining ones to various insects. The titles now appear quaint, as shown by the following examples: X, of "Flyes," XVII, grasshoppers and "krickets," XVIII "of moths called Blattae," XXIX, of the "wall-louse or winged Punie." Book II is about insects without wings, caterpillars, especially silk spinners, and other creatures. Some of the chapter headings are: VI, of the "whurlworm," VII, "of a caterpillar called Staphylinus," IX, "of Chisleps or pill bugs," XIII, "tame or house spider," XXII, "six footed worms in living creatures and of lice in men." Short chapters deal with such miscellaneous creatures as "horseleeches," water worms, sheep lice, mites, clothes moths, fleas and water insects. The "physical index" added by Roland refers to the pages of the book whereon are listed remedies for various diseases of man.

Some of the accounts are quite lengthy and show much diligence and knowledge of the writings of ancient authors, whose beliefs and mistakes were repeated by Moffett. Quotations are numerous, and the names of Aristotle, Pliny, Cardan, Galen, Marcellus, Bellonius, Lonicerus, Cordus, Altius, Homer, Plato, Gesner, Democritus, Varro, Pindar, Socrates, Africanus, Scaliger, Suetonius, Plutarch, Aristophanes, etc., appear frequently. Apparently few original assertions are included. In some places Moffett includes the results of his own observations during his travels or about London, and speaks of receiving specimens of "Cerambyces" from Quickelbergius, of Antwerp, and of giving specimens to Dr. Penny. In general, Moffett's treatment of each species gives the name of the insect in Hebrew, Italian, French, etc., the opinions of the Greeks concerning it, a rough description interspersed with remarks by Pliny, Socrates, etc., a statement about the structure, breeding habits and food plants of the species according to various authors and travelers, and then an account of the myths surrounding the insect and its uses in medicine. His treatment varies somewhat with the different species, depending upon the amount of material available.

The only attempt at classification is a table in which all insects "without wings" are divided into two groups, those inhabiting the earth and those the water. The "earth" insects are divided into "some with feet" and "some without feet" as earthworms and "mawworms." The "some with feet" include those that "goe with many feet; catterpillers, beetles and such as are called Staphylni," those that "goe with eight feet, scorpions and spiders" and those with six feet, such as "wasps, glow worms, the female Meloe. Also worms in wood, trees, roots, fruits, meats, garments, chambers, humors." The water insects, too, are divided into those "without feet," as the hair-worm and "horsleech," and those "with feet." The latter includes those swimming with six

feet, such as "the Shrimp, the Lake Scorpion, the Notonectus" and those "with many feet" as the "Sea Scolopendra, the many footed Shrimp."

Some of the remedies proposed in Moffett's book seem quite bizarre at this time, as the following quotations show:

Concerning the use of bees in baldness:

Take bees dead in the combs, and when they are through dry make them into powder, as Galen in Euporist. writes, mingle them with honey in which they died, and anoint the parts of the head that are bald and thin haired, and you shall see them grow again.—Page 906.

Propertius is the author of the following distich:

That which forbids the nasty Fly the dish to lick,
Is Peacock's feathers fastened to a stick.
—Page 947.

When cowes or calves are sick, and bellies swell,
They 'ave eat Buprestis keepers known full well.
—Page 1000.

Pliny saith that the Buprestis by way of corrosive doth take away Ringworms in the face. Hippocrates doth much commend them in divers diseases of the womb.—Page 1002.

Faventinus prescribes 21 Chislops boyled in sowr Oyl, for pains in the ears proceeding from cold; in which he shows that they must be annointed about the ears, and a little must be dropped in.—Page 1049.

If you often apply Oyl or Buttor of Hog-lice to a pained head, you shall cure the pain. *Gal. Eupor.* 2.91. Bruised, they cure the Tonsils, and the diseases of the chops, *Dioscor.*—Page 1049.

Concerning cosmetics:

A Maid that cares for her beauty, and would make the circles of her eye-lids black, Emmets eggs bruised with Flies will perform that, and give them their desire.—Page 1080.

For toothache:

Rub a faulty tooth with the Worms in Coleworts, and it will in a few dayes fall forth itself.—Page 1088.

According to Galen:

Worms that breed in hollow and rotten trees heal secret Ulcers and all symptomes of Ulcers, and diseases of the head.—Page 1088.

That trees may not be eaten with worms, plant them in the new of the Moon, and cut them down between the new and old Moon in the conjunction. Also annoint them with Tarre, and often wet them with the lees of Oyl.—Page 1089.

Moffett's magnificent compilation, illustrated by what now would be called wretched woodcuts, was praised by Haller in his notes on Herman Boerhaave's "Methodus Studii Medici." Haller lauded the large amount of information presented about each species and also praised the illustrations. He admitted that Moffett believed too many legendary reports, but placed him above all entomologists before Swammerdam. Hallam did not rate Moffett so highly.

Moffett's other posthumous book, compiled about 1595, was: "Health's Improvement; or Rules comprising and discovering the Nature, Method, and Manner of Preparing all sorts of Food used in this Nation. Written by that ever Famous Thomas Muffett, Doctor of Phisick; corrected and enlarged by Christopher Bennet, Doctor of Physick and Fellow of the Colledg of Physitians of London" (London 1655). According to the account in the "Dictionary of National Biography," on which the present paper is based, his second posthumous book is a loquacious assemblage of rules relating to diet. A second edition was published in 1746. It was Moffett's intention to supplement this by a like book on "drinks."

From all accounts, Moffett had considerable reputation as a physician, chemist and naturalist. Well grounded in the classics, mathematics and medicine, his experience enriched by travel, his association with persons of rank, his knowledge of music, his literary aptitude, as indicated by his books and poem on the silkworm, which Chamberlain said was "no bad piece of poetrie," all

point to high intelligence and culture. Of a religious bias, in the preface of his book on insects, he says, speaking of large animals—"I acknowledge God appears in their magnitude, yet I see more of God in the History of lesser Creatures." With the godless he had little patience, as the following extract, from the preface to the second part of his "Theater of Insects," bears witness:

> Go to therefore bold Atheist, who art ignorant of God and the Divine Perfection; endure, if thou canst, the biting of the Spider Phalangium, or of the Scorpion; abide the pain of the Worm Scolopendra; swallow down the Pine-tree Catterpiller, Contend with Worms, despise with Herod, biting Lice, so much as thou art able, at last thou shalt finde that there is no foot Souldier so mean in this Army, that will not quickly overcome all the forces of thy body and minde, and will make thy foul mouth to confess, by their ministry, that there is a God. Thus then I draw forth my Regiments, so I muster the Souldiers.

Moffett lived at a time when the love of gold and jealousy of Spain were the activating forces behind English navigation; when the control of the seas passed from Spain to England; when Sir Walter Raleigh was making unsuccessful attempts to settle Virginia; when England's colonial expansion started; when the author and publisher of a book that displeased Elizabeth had their right hands cut off with a butcher's knife and mallet in the market place at Westminster; when England was being raised to a first-class power in Europe through Elizabeth and her advisers; when "Gammer gurtons Nedle, a Ryght Pithy, Pleasaunt and merie Comedie" was played in Cambridge; when, according to the "Boke of Nurture, or Schoole of good manners," children were exhorted to say their prayers, brush their clothes, wash their hands, comb their hair, and not to pare their nails at the table, nor pick their teeth with a knife and not to be noisy with their soup or blow upon it; when William Clowes, surgeon, characterized scrofula as a disease known to be cured by the sacred hands of the Queen; when Elizabeth wanted to be considered beautiful and to be loved and when she called the Duke of Alençon her "little frog."

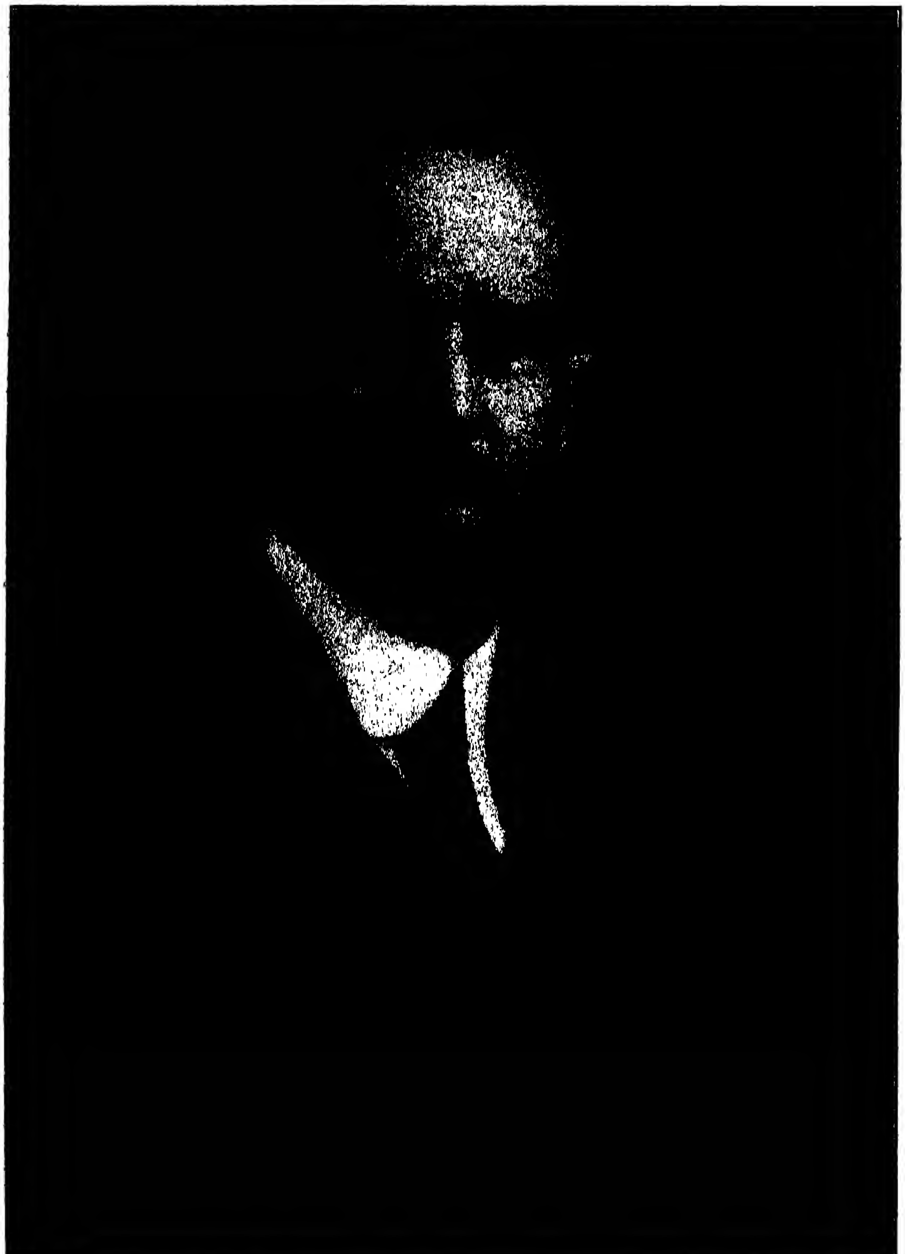
THE PROGRESS OF SCIENCE

EDITED BY DR. EDWIN E. SLOSSON
Director of Science Service

RESEARCHES DESCRIBED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

AMONG reports of general scientific interest presented at the annual meeting of the National Academy of Sciences, held in Washington on April 23 and 24, was a paper by Professor R. W. Wood, of the Johns Hopkins University, describing the work which he and Mr. A. L. Loomis have conducted on sound waves of high frequency. These rays of inaudible sound waves are produced from slices of quartz crystal, driven by oscillating electric currents of frequencies of about 500,000 a second. They travel through any liquid or solid object and heat it as they go, but do not come out into the air. Blood corpuscles in a physiological salt solution are broken down, tingeing the whole body of the fluid a clear red; but if a tiny particle of gelatin—half a per cent. or less—is added, it somehow protects the corpuscles and they are not broken. If a block of artificially frozen ice is subjected to their action, the waves have no apparent effect on it until it is placed under pressure, when it at once breaks into a mass of tiny crystals. But a piece of pond ice, frozen under different conditions, resisted the waves and did not crumble. Finely powdered solids, stirred up in water to make a suspension, are driven together by the waves, until they form a closely packed round mass just under the surface. Things that can not ordinarily be mixed with water, like oil, paraffin and mercury, are forced by the vibrations to become exceedingly fine suspensions or emulsions. A paraffin candle was floated on water and the current turned on. The wax melted from the surface and came down into the liquid in the form of a cloud of microscopic white drops, forming a veritable paraffin milk. In another experiment, a little mercury was poured on the bottom of the beaker full of water. The waves broke it up into drops so small that they could just be seen with the highest power of the microscope, scattered evenly through the water in a dense cloud. This mercury-water emulsion was as black as ink.

THE studies of Dr. F. E. Wright, of the Geophysical Laboratory of the Carnegie Institution of Washington, which he described at the meeting of the academy, indicate that the surface of the moon consists of such rock as pumice and granite, with no basalt. And as basalt is almost invariably associated with volcanic activity as far as we know, this is rather a jolt to the theory that the moon was once the scene of vast volcanic activity, producing the craters that are such a familiar feature of its surface. The light reflected from the moon is partly polarized, and by determining the degree of polarization it is possible to learn something of the nature of the reflecting surface. At different phases of the moon, the light is reflected to the earth at different angles, and by comparing with it the polarization of light reflected from earthly rock surfaces, Dr. Wright has found that rocks containing large amounts of silica, such as pumice, granite, quartzporphyry, as well as sulphur and powders of transparent substances, polarize light reflected from their surfaces much in the same way as the moon does. But basalt, a rock due



DR. THOMAS HUNT MORGAN

Professor of experimental zoology in Columbia University, who has been elected president of the National Academy of Sciences to succeed Professor A. A. Michelson.

to volcanic causes, affects the light quite differently. At best, however, the amount of polarized light reflected from the moon is very slight, and at new moon and full moon is practically absent.

WHAT seems to be a solution of the problem of how the heat and light radiated from the sun vary was announced by Dr. C. G. Abbot, acting secretary of the Smithsonian Institution. While it has been known for nearly a century that the sun undergoes an eleven-year cycle during which sun spots wax and wane, and that the intensity of the radiation follows somewhat in step, the correspondence is not close enough to permit advance predictions of what the radiation will be. Dr. Abbot took values for the intensity of solar radiation found by the Smithsonian's Astrophysical Observatory for a period of 77 months, ending October, 1926. These were analyzed by Dr. Dayton C. Miller, of the Case School of Applied Science, in an ingenious machine of his invention, known as the harmonic analyzing machine. The results show that there is a marked period of about 25 2/3 months, and two others less strongly marked of 15 2/5 months and of 11 months. The combination of these periods produces a very complicated variation, which has hitherto been supposed to be without any regularity whatever. As the sun affects terrestrial conditions, such as long range radio reception, and as it has already been found that the world's rainfall average undergoes a variation of 15 2/5 months, corresponding with the one Dr. Abbot has found in solar radiation, he is hopeful that prediction of the intensity of solar radiation, and the effects attendant on it, may soon be possible.

THE loss in weight that we all undergo every day, mostly water given off through the skin and lungs, has been the object of research by Dr. Francis G. Benedict and Cornelia Gollay Benedict, of the Carnegie Institution of Washington. Two sensitive balances were used in the work. Both were strong enough to sustain the weight of a man, but sensitive enough to register small changes in weight. One of the balances would indicate a change of one third of an ounce, and was so constructed that the volunteer for the experiment could sleep all night on its platform. The other was a hundred times as sensitive, but could be occupied for only an hour or so at a stretch. The total moisture losses of this class from a woman of average weight were found to average about 30 grams, or one ounce, per hour; for a man the figure was about a third higher. An auxiliary device permitted the separate measurement of losses from the lungs and skin, and while these varied among individuals and from time to time in the same individual, they averaged 50 per cent. from each source of water loss. Other ingenious mechanisms measured the carbon dioxid given off, the percentage of water in the outgoing breath and also its temperature.

USING an electrical heat-measuring device so incredibly delicate that it is sensitive to two trillionths of an ampere of current and will measure temperature changes of as little as one ten-millionth of a degree Centigrade, Dr. A. V. Hill, of the University of London, has measured the temperature changes in nerve fibers during their activity. In describing his experiments before the academy, he stated that his object had been to learn more about the nature of nervous action. Older theories have held that nervous impulses were not like other physiological processes, but were physical waves like light or radio waves. These ideas were based on the absence of any detectible heat given off by

BENEDICT DE SPINOZA

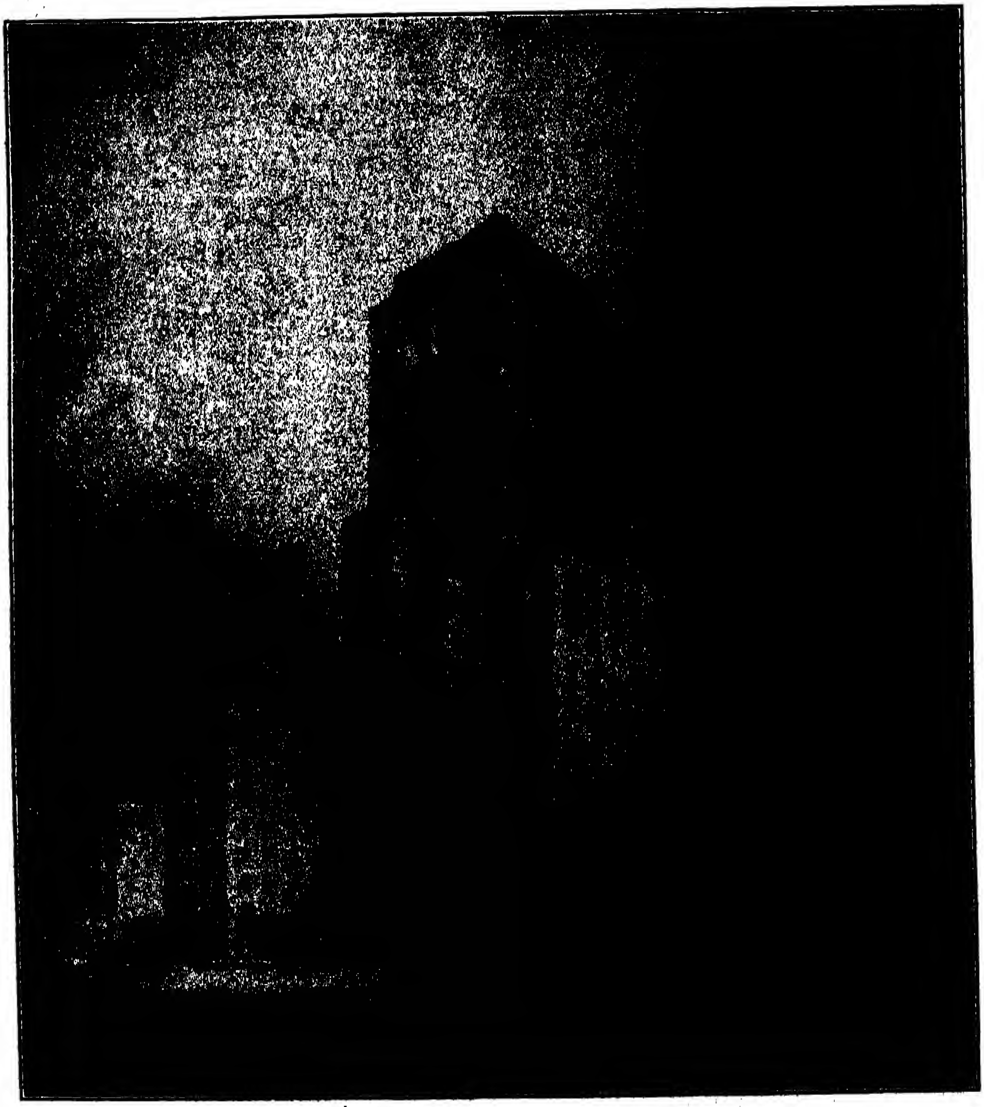
THE GREAT DUTCH PHILOSOPHER, THE TWO HUNDRED AND FIFTIETH ANNIVERSARY OF WHOSE DEATH IS THIS YEAR BEING WIDELY COMMEMORATED.

nerves as a result of stimulation. But with the extremely sensitive instrument devised by Dr. Hill it is possible to measure the almost vanishingly minute temperature rise that occurs in a single nerve fiber when it is caused to react. The moment of activity of a nerve is followed by a prolonged period of recovery, during which nine times the initial amount of heat is given off.

CHEMICAL methods to arouse seed potatoes and other plant cuttings from their lethargy and start them into growth weeks before the usual time were described by Dr. Frank E. Denny, of the Boyce Thompson Institute, Yonkers, N. Y. Potato tubers when freshly harvested are dormant, and will not sprout if planted at once under growing conditions, the rest period lasting from 1 to 4 months in different varieties of potatoes. This period of inactivity may be shortened by treating the tubers with various chemicals. The gain in time of sprouting is about 2 to 6 weeks, depending on the variety of potato and the stage of dormancy at the time the treatment is applied. Twigs of apple, grape, lilac, also have this dormant period in autumn, and the buds of these species can be forced into early growth by treatment with certain of these chemicals, the gain in time of budding or blooming ranging from 1 to 9 weeks. The chemicals used by Dr. Denny include thiocyanates, thiourea and ethylene chlorhydrin.

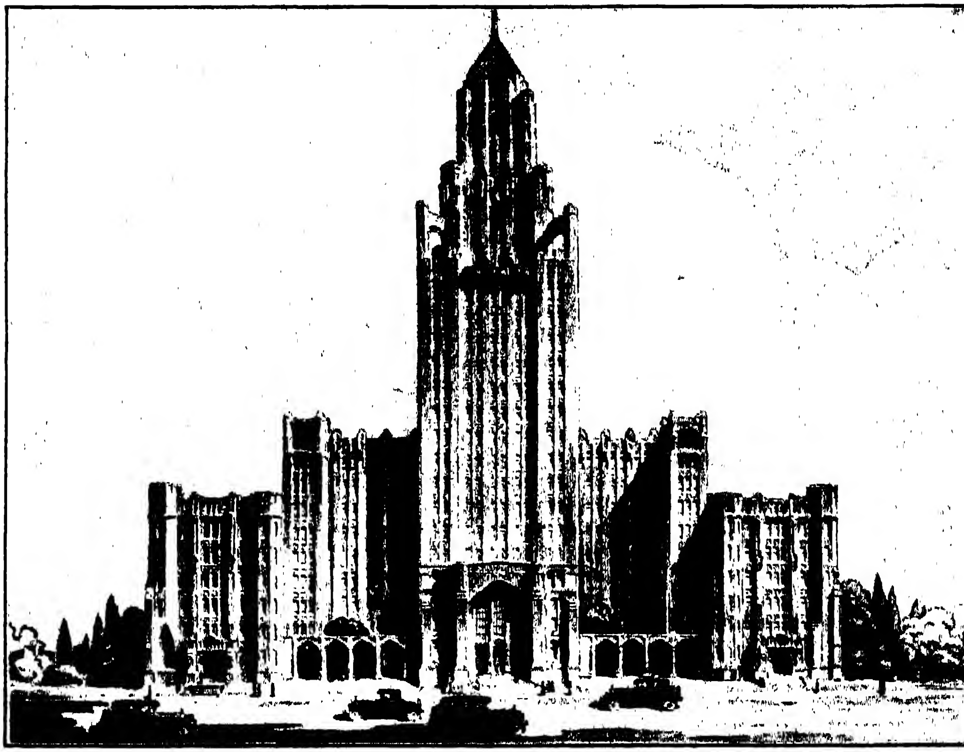
BORING for live steam as men bore for oil, with the possibilities of running engines and turning dynamos without the burning of fuel, was described by Dr. Arthur L. Day, of the Carnegie Institution of Washington. The steam wells are in Sonoma County, Calif., where operations have been going on for some time to exploit a field of hot springs and steam vents similar to those of Yellowstone National Park but on a smaller scale. So far five borings have been sunk. They reach depths of from 300 to 600 feet, yielding a total of nearly 5,000 horsepower of live steam. The temperatures at the bottoms of the wells vary from 160 to 185 degrees, and the pressures attain a maximum of 276 pounds per square inch. Besides steam, various gases come out of the wells, making up less than two per cent. by volume of the product. Similar wells have been operated on a large scale for several years in Italy. Concerning these, Dr. Day remarked, "Compared with the development of natural steam in Tuscany, where more than 30,000 H.P. is now commercially developed, the conditions in California appear to be somewhat more favorable from the point of view of the uncondensable gases carried and their corrosive effect upon metals. The total power available is probably smaller. The oldest of the California wells has now been flowing intermittently for five years with undiminished pressure."

"SEA-LEVEL," the standard to which land heights are referred, is not such a definite thing, Professor Douglas Johnson, of Columbia University, told members of the academy. Local configurations of the shore line may have a great effect, and as extreme examples of the effect he cited the case of the Bay of Fundy, which is wide at the mouth, but gets narrow towards the head, so that the high tide in the bay is much higher than in the open sea. On the other hand, a broad bay, connected to the sea by a narrow inlet, may never have a tide as high as in the ocean outside because the water can not pour in through the inlet fast enough to fill up the bay before the tide outside begins to fall again. These are extreme cases, but that much less clearly marked irregularities of the coast may produce considerable effect



THE NEW YORK STATE PSYCHIATRIC INSTITUTE AND HOSPITAL

ARCHITECT'S DRAWING FOR THE BUILDING WHICH IT IS PLANNED TO ERECT AS PART OF THE MEDICAL CENTER WHICH INCLUDES THE MEDICAL SCHOOL OF COLUMBIA UNIVERSITY.



TEMPLE UNIVERSITY
SKETCH OF THE BUILDING WHICH IT IS PROPOSED TO ERECT IN PHILADELPHIA. THIS LIKE THE PRECEDING PICTURE ILLUSTRATES THE APPLICATION OF AMERICAN ARCHITECTURE TO ACADEMIC AND PUBLIC BUILDINGS.

has been shown by studies around the city of New York. In some places the crest of high tide was found to be nearly two feet higher than others. On this account any local changes in the shore-line may affect the mean sea-level, and so produce an apparent settling or rising of the coast line.

THE fossil-bearing rocks of the Grand Canyon, which have recently aroused much interest because of the discovery in them of footprints of long-extinct animals, are now yielding remains of the leaves and stems of plants among which these animals roamed and fed many millions of years ago. At the meeting of the academy Dr. David White, of the U. S. Geological Survey, told of his examination and identification of many specimens from this region. The plants that grew on the ancient floodplain of red sand through which the great gash of the Grand Canyon has since been cut were very little like the ones that grow in the forests of to-day. Their nearest relatives still living are the ferns and the tropical cycads and similar plants. The plant remains were all preserved by being deposited at the bottoms of streams or ponds, but there is evidence that these bodies of water were not permanent, but appeared during rainy seasons and dried up when the rains ceased.

THE CHILDHOOD OF GREAT MEN

From Punch

BENJAMIN FRANKLIN, AT THE AGE OF FIVE, HAS AN IDEA THAT LIGHTNING MIGHT BE BETTER CONDUCTED.

LITTLE CHARLES DARWIN BEGINS TO CONSIDER.

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